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THE REACTION OF HOMEOWNERS ALONG THE NORTH SASKATCHEWAN VALLEY IN EDMONTON TO THE EROSIONAL HAZARD

by

© PATRICK WILLIAM NAUGHTON

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF GEOGRAPHY

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled THE REACTION OF HOME-OWNERS ALONG THE NORTH SASKATCHEWAN VALLEY IN EDMONTON TO THE EROSIONAL HAZARD, submitted by Patrick William Naughton in partial fulfilment of the requirements for the degree of Master of Science.

Date 26th November 1971

ABSTRACT

In this thesis the reactions of homeowners who live along the North Saskatchewan River Valley to the erosional hazard are studied. The primary emphasis is on the adjustments that residents could take as a result of the occurrence of erosion.

It was hypothesized that people perceive the erosional hazard when they establish their residency on the top of the river valley. This hypothesis proved to be untrue, though it was found that at the present most people perceive it. A relationship was found to exist between well-educated persons and a high percentage of perception at present. Other correlations concerning investment and pessimism were inconclusive.

The major emphasis was placed on adjustments: technical and social. Over 80 per cent of the sample felt that technical adjustments could prevent the occurrence or reoccurrence of erosion. To investigate the social adjustments it was necessary to determine responsibility for recovery of loss, that is whether one assumes one's own responsibility and absorbs the financial loss from natural erosion or whether one places this responsibility on an outside influence, agency, or group. Over 60 per cent realized

that there was no one else to whom they could go to recover loss, while the remaining respondents felt it was the responsibility of insurance firms or one or more levels of government. Through inquiries made to City insurance firms it was found that insurance is not a possible alternative to which residents can turn for recovery of financial loss. Governmental statutes (City, Provincial, and Federal) likewise show that erosional loss is the risk of the homeowner. The only method found whereby a homeowner can recover loss due to natural erosion is through proof of negligence by the construction firm or engineering consultant that was involved in the planning of his home. The conclusion that must be drawn from this study is that those who live along the river valley must accept the risk of their choice of home site.

The significance of this thesis can be said to be the discovery of a lack of knowledge among homeowners concerning two aspects. There is a lack of perception of the possibility of erosion occurring when one establishes a residence at the top of the valley slope. There is also a lack of knowledge about the social adjustments of homeowners insurance and government policies concerning the erosional hazard.

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The efforts of Mr. J. Chesterman in reproducing the maps and photographs is acknowledged, special thanks is extended to Mrs. S. Kucharyshyn for her cartographic advice. The competent typing of the final copy by Mrs. Laura Zornes is gratefully recognized.

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CHAPTER I

BACKGROUND, THE PROBLEM, HYPOTHESIS, AND METHODOLOGY

I. BACKGROUND

The interaction of man, his environment, and his spatial behavior is not a "recent discovery" in Geography. Barrows,[1] in 1923, in his Presidential Address to the Association of American Geographers felt it should be the geographers aim:

> *...to make clear the relationships existing between natural environments and the distribution and activities of man. Geographers will...be wise to view this problem in general from the standpoint of man's adjustments to environment, rather than from that of environmental influences.*[2]

Downs[3] indicates that the emphasis on perception is part of a general trend in modern geography which he has labelled the "Behavior revolution." Other

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[1] H. H. Barrows, "Geography as Human Ecology," A.A.A.G., Vol. 13, No. 1, March 1923, pp. 1-14.

[2] Ibid., p. 3.

[3] R. M. Downs, "Geographic Space Perception: Past Approaches and Future Prospects," Progress in Geography, International Reviews of Current Research, Vol. 2, C. Board et. al. (Editors), Edward Arnold Publishers, London, 1970, pp. 65-108.

social sciences have long recognized that man, as such, must be taken into account as a variable when dealing with his environment. This is a major field in psychology. Perception geography in this modern trend, becomes an "environment/man/spatial behavior" relationship.[4]

Bartley noted that perception (in psychology) "...is the overall activity of the organism that immediately follows or accompanies energistic impingements[5] upon the sense organs."[6] To the psychologist perception relates to an output-input concept, the output is "...the behavior of the organism (and) is related to some aspect of the input, or stimulation, impinging on the organism."[7] The geographer, when studying perception, is not concerned with these neurological and psychological aspects but rather with social perception. Social perception "...is generally concerned with the effects of social and cultural factors on man's cognitive structuring of his physical and social environ-

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[4]Ibid., p. 68.

[5]"energistic impingements" - stimuli from the physical world.

[6]S. H. Bartley, Principles of Perception, Harper and Bros., New York, 1958, p. 22.

[7]W. N. Dember, The Psychology of Perception, Henry Holt and Co., New York, 1960, p. 7.

ment."[8] Therefore it can be seen that the stimuli present and the mechanics of the sense organs are only part of the interaction that produces social perception (hereafter perception is used as being synonymous with social perception). The individual's perception is dependent on "...past history and present 'set' or attitude acting through values, needs, memories, moods, social circumstances and expectations."[9]

It could be possible to confuse perceptions and attitudes as they are both developed from experience. An attitude is a stable concept while perception is limited to a short time span.

> *Attitudes are learned, and they can be acquired in the same way as anything else is learned - through classical and instrumental conditioning, through concept formation, through observing other people's attitudes and through being openly taught to hold certain attitudes. Perceptions are more transitory than attitudes, less stable and more subject to change with immediate past experience and present state of the perceiver.*[10]

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[8] H. Tajfel, "Social Perception," in International Encyclopedia of the Social Sciences, D. L. Sills (Editor), Macmillan Co. and Free Press, New York, Vol. 11, 1968, p. 567.

[9] T. F. Saarinen, Perception of Environment, A.A.G., Resource Paper No. 5, 1969, p. 5.

[10] M. R. Schiff, Some Theoretical Aspects of Attitudes and Perception, Univ. of Toronto, Natural Hazard Research Working Paper No. 15, 1970, pp. 10-11.

It is important to note that perception is limited to a situation where a physical stimulus or set of stimuli are present.

The investigations into the interrelationships of man, his environment, and spatial behavior have, in general, been concerned with one element of the environment (as is this paper). Within the past five years there have been several excellent studies completed on several elements together of the natural environment.[11] Mental mapping and transects have also been used in environmental studies.[12]

White's[13] 1945 paper on adjustments to flood hazard is considered to be one of the first major papers in geographical perception. White, and many of his students from the Department of Geography at the University

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[11] T. F. Saarinen and R. U. Cooke, Public Perception of Environmental Quality in Tucson, Arizona, Univ. College London, Dept. of Geogr. Occasional Paper No. 9, 1970, 27 pp.; and K. Hewitt and I. Burton, The Hazardness of a Place, Extreme Events in London, Ontario, Univ. of Toronto Press (in Press).

[12] K. Lynch, Image of a City, M.I.T. Press, Mass., 1966, 194 pp.; and D. Appleyard, K. Lynch, and J. R. Myer, "The View from the Road," in Environmental Perception and Behavior, D. Lowenthal (Editor), Univ. of Chicago, Dept. of Geogr. Research Paper No. 109, 1967, pp. 75-88.

[13] G. F. White, Human Adjustment to Floods: A Geographical Approach to the Flood Problem in the United States, Univ. of Chicago, Dept. of Geogr. Research Paper No. 29, 1945, 236 pp.

of Chicago have been classified by Downs,[14] as the "Chicago School" because of their basic approach to environmental studies. The studies of natural hazards in the natural environment, under the influence of the "Chicago School," have employed a basic research design to identify five objectives.

> (a) assess the extent of human occupance in hazard zones;
>
> (b) identify the full range of possible human adjustments to the hazard;
>
> (c) study how men perceive and estimate the occurrence of the hazard;
>
> (d) describe the process of adoption of damage reducing adjustments in their social context; and
>
> (e) estimate the optimal set of adjustments in terms of anticipated social consequences.[15]

Burton and Kates[16] have defined a natural hazard as an element "...in the physical environment, harmful to man and caused by forces extraneous to him."[17] A natural hazard is a direct result of man and his attempts at resource management. In other words, without man, a flood or other natural event would be a natural phenomena, it is only when man is concerned that hazards occur.

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[14] Downs, op cit., footnote 3, p. 95 .

[15] R. W. Kates, Natural Hazard in Human Ecological Perspective: Hypotheses and Models, Univ. of Toronto, Natural Hazard Research Working Paper No. 14, 1970, p. 2.

[16] I. Burton and R. W. Kates, "The Perception of Natural Hazards in Resource Management," Natural Resources Journal, Vol. 3, 1964, pp. 412-441.

[17] Ibid., p. 413.

> *...the management of resource use brings man into a closer contact with nature (be it viewed as friendly, malevolent, or neutral) where the extreme variations of the environment exercise a much more profound effect...*[18]

> *The way men view the risks and opportunities of their uncertain environment plays a significant role in their decisions as to resource management.*[19]

It is this view which is the basis for perception studies in geography.

A major interest in hazard studies is that of the adjustments which are open to the individual. Theoretically there are a wide range of adjustments open to the individual, these are "...the number of adjustments and uses that have been practiced in any similar environment, plus a possible innovation."[20] It is recognized that no individual has the total theoretical choices open to him. There are restraints, such as culture, education, previous experience, and attitudes, that may limit his choice of adjustments. Adjustments may be divided into types (1) technological and (2) social. Technological adjustments include all actions that "...are directed to affecting the

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[18] Ibid., p. 417.

[19] R. W. Kates, Hazard and Choice in Flood Plain Management, Univ. of Chicago, Dept. of Geogr. Research Paper No. 78, 1962, p. 1.

[20] G. F. White, "The Choice of Use in Resource Management," Natural Resource Journal, Vol. 1, 1961, p. 27.

cause of the problem or to modification of the hazard itself."[21] The major social adjustments have been divided into two divisions and are identified:

> *...as being on the one hand psychological (largely relevant to individual behavior), and on the other socio-economic (relevant to the behavior of groups or the behavior of an individual with respect to groups).*[22]

II. THE PROBLEM

In Edmonton (Figure 1) the valley of the North Saskatchewan River is liable to serious erosion, both natural and man-induced (Figure 2). The primary problem investigated was the perception of the erosional hazard itself. If people perceived the hazard a secondary problem developed, did they preceive it as possibly causing financial loss to themselves? These two perception problems lead to a question on the level of knowledge. Is the owner-resident aware of the government statutes and private insurance policies that apply to erosion and to his homesite?

It should be emphasized that though this is a hazard

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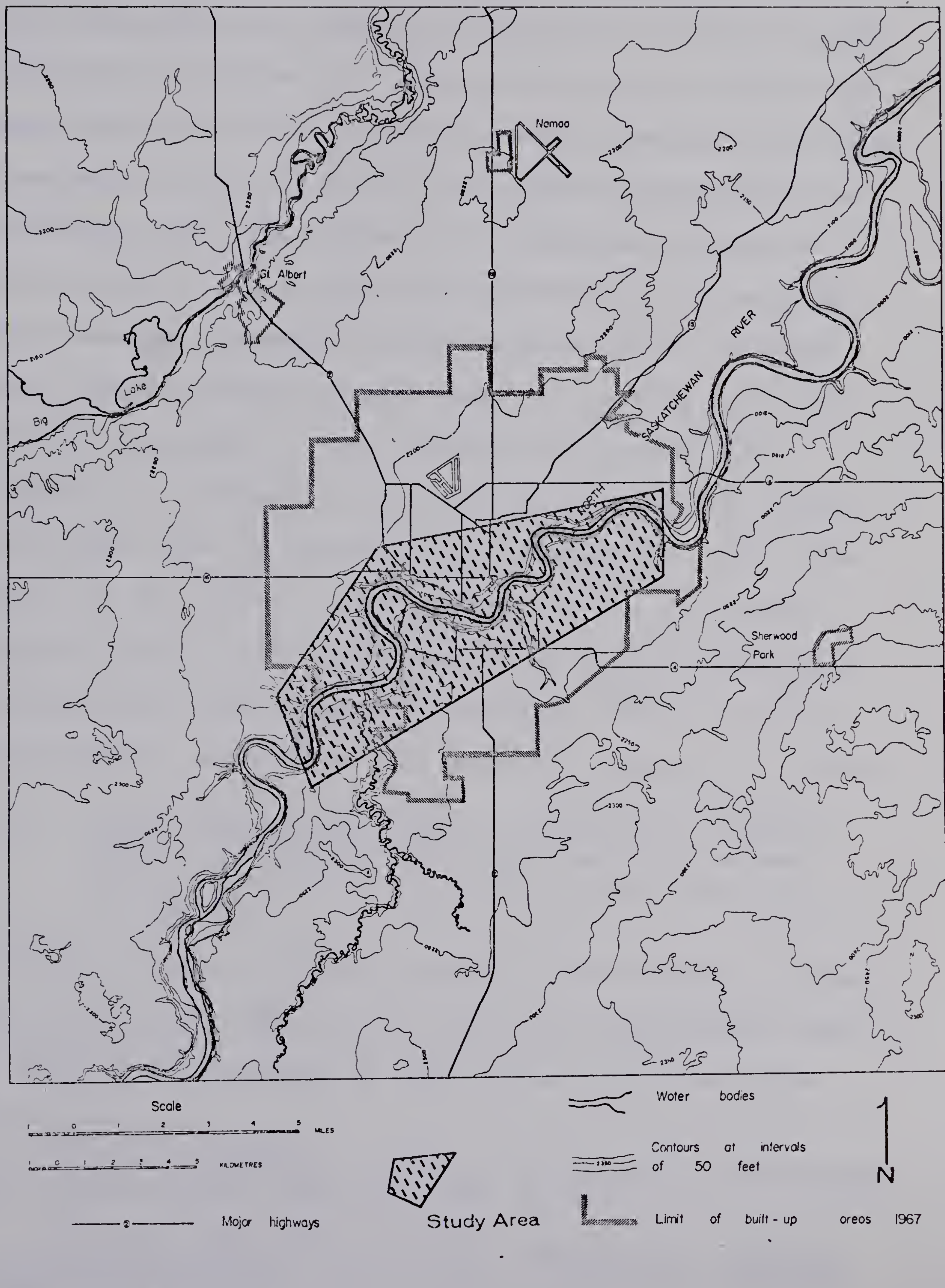
[21] I. Burton, R. W. Kates, and G. F. White, The Human Ecology of Extreme Geophysical Events, Univ. of Toronto, Natural Hazard Research Working Paper No. 1, 1968, p. 13.

[22] R. G. Golledge, Process Approach to the Analysis of Human Spatial Behavior, Ohio State Univ. Dept. of Geogr. Discussion Paper No. 16, 1970, p. 12.

EDMONTON Figure 1



study the geomorphic processes under consideration are not on the same scale as a disaster (though the possibility will be discussed in Chapter 4). The processes only affect a few persons and even then only with financial damages rather than endangerment to life or limb. The complex geomorphology of the Edmonton area (see Chapter 2) produces many types of natural erosion, and through man's inability to understand proper resource management he has induced further erosion. Natural and man-induced erosion applies, in this study, to exogenetic processes. These exogenetic processes are "...applied to processes originating at or near the surface of the earth, such as weathering and denudation..."[23] Mass movement is the largest, in magnitude, of the exogenetic processes active on the river and ravine slopes in Edmonton. The first major mass movement in Edmonton, during the historical period, occurred on Grierson Hill (Figure 2) in 1893.

> *Since that time the top of the bank has receded about 75 feet and forced the removal of houses along the south side of 101st Avenue about 1912 or 1913.*[24]

The top of the bank retreated another 50 feet during a large landslide in 1915. The river in 1957 was approximately 400 feet south of its position in 1893. Since the latter date

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[23]A. C. Trowbridge (Editor), Dictionary of Geological Terms, Dolphin Books, New York, 1962, p. 169.

[24]R. M. Hardy and Associates, Report Re: Grierson Hill, Edmonton, Alberta, for the City of Edmonton, Engineering Dept., Unpublished report, 1953, p. 3.

"...the bank movements have pushed the river out substantially and therefore river erosion is not presently a factor in the causes of the instability."[25] The indications of the preliminary research are that seepage into the bentonitic bedrock has been the major cause of instability. Seepage water was found in enormous quantities in old coal shafts under Grierson Hill, it is thought that this was the main cause of major movements occurring there.[26]

There have been several other studies on slope instability in the Edmonton area. Painter[27] conducted an engineering survey of the LeSueur block glide to the east of the City. Common[28] used Edmonton as an example of the effects that slope failure can have on the transportation network. Thomson[29] discussed the stability of the river

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[25]R. M. Hardy and Associates, Second Report Re: Grierson Hill, Edmonton, Alberta, for the City of Edmonton, Engineering Dept. Unpublished Report, 1957, p. 6.

[26]J. D. A. Macdonald (City Engineer), Memorandum to the City Commissioners, Re: Grierson Hill, City of Edmonton, March 29, 1957, p. 1.

[27]W. T. Painter, An Investigation of the LeSueur Landslide, Edmonton, Alberta, Dept. of Civil Engineering, Univ. of Alberta, Unpublished M. Sc. Thesis, 1965, 101 pp.

[28]R. Common, "Slope Failure and Morphogenetic Regions" Essays in Geomorphology, G. H. Dury (Editor), Heinemann, London, 1966, pp. 53-81.

[29]S. Thomson,"Riverbank Stability Study at the University of Alberta, Edmonton," Canadian Geotechnical Journal, Vol. 7, 1970, pp. 157-168.

bank adjoining the campus of the University of Alberta in order to determine the possible use of it for building sites.

The importance of slope failure is evident in Edmonton as man encroaches on the river valley. Problems are created as land adjacent to the river and ravine system is developed, serviced, and homes are constructed. Homesite construction often upsets the delicate balance, or equilibrium of the slopes. The vegetative cover is removed, and fill is used to level off topographic irregularities and to claim additional flat property from the river valley slope.

The physical stimulus in this perception study is the natural erosion while the social and cultural factors are education, occupation, and attitudes in the society (whether real or imagined).

III. HYPOTHESIS

In order to investigate the problems, as stated above, it was necessary to develop hypotheses which could be statistically tested. The major hypothesis attempts to answer one question: Do people perceive the hazard when they establish their domicile along the top of the river valley? Secondary hypotheses have been included as subsections under the main one and are tested separately.

The major hypothesis is:

> In Edmonton, people perceive the erosional hazard when they establish their domicile along the top of the bank of the North Saskatchewan River Valley.

The secondary hypotheses are:

(a) People with higher levels of education are more aware of the hazard.

(b) Those homeowners who live in areas that have higher assessment rates are more aware of the erosional hazard.

(c) The older a person is the more pessimistic he is about future occurrences of the hazard.

(d) People do not believe there are technical preventive measures which can be taken to stop or reduce erosion.

The major hypothesis and the first three secondary hypotheses are investigated in the third chapter. The last secondary hypothesis will be dealt with in the fourth chapter.

IV. METHODOLOGY

In order to test the hypotheses, it was decided, in the research design, that the questionnaire would be the best method with which to collect data. Several researchers have disagreed with the use of the questionnaire by human geographers as the only means for collection of data. Downs felt that geographic space perception should "...be developed in close cooperation with research in the spectrum formed by psychology, social psychology, and sociology."[30] There have been several studies completed that have applied various

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[30] Downs, *op. cit.*, footnote 3, p. 83.

psychological tests to geography, it is interesting to note that while psychological tests have been used in geography they have often been administered in conjunction with a questionnaire.

The thematic apperception test was developed by Murray[31] in 1943 and "...makes it possible to trace the sequence of events involved in a decision-making situation posed by a particular..." threat.[32] It was believed that this test provided "...deeper insights than the conventional geographic techniques into the reactions of individuals confronted by any number of different environmental situations."[33] The photo-slide test has been used by several authors (Sonnenfeld[34] and Coughlin and Goldstein[35]) as a rating test of perception and agreement on attractiveness of the physical environment. The Rosenzweig picture-frustration test was developed at approximately the same time as the thematic apperception test, and has since been widely used in psycho-

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[31] H. A. Murray, Thematic Apperception Test: Pictures and Manual, Harvard University Press, Cambridge, Mass., 1943, footnote 35, 56 pp.

[32] J. Simms and T. F. Saarinen, "Coping with Environmental Threat: Great Plains Farmers and the Sudden Storm," A.A.A.G., Vol. 59, No. 4, 1969, p. 679.

[33] Ibid., p. 686.

[34] J. Sonnenfeld, "Environmental Perception and Adaptation Level in the Arctic," in Environmental Perception and Behavior, op. cit., footnote 12, pp. 165-169.

[35] R. Coughlin and K. Goldstein, The Extent of Agreement Among Observers on Environmental Attractiveness, Regional Science Research Institute, Discussion Paper Series, No. 37, Feb. 1970, 56 p.

logy.[36] It has been adapted to geographical perception studies in the hope of examining the "...cultural differences in response to natural hazards."[37] The sentence completion test could possibly be said to be a written form of the Rosenzweig picture-frustration test,[38] and was suggested as being an excellent perception test as it is designed to produce responses relevant to three areas: (1) the range of responses, (2) the emotions, and (3) the psychological dimension of internal versus external control.[39]

A semi-formal or structured questionnaire, conducted as a personal interview, was the method chosen to collect data.

> *The case for formal interviewing is simple. Only if all respondents are asked exactly the same questions in the same order can one be sure that all the answers relate to the same thing and are strictly comparable. Then, and then only, is one justified in combining*

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[36] S. Rosenzweig, "Picture-Association Method and Its Application in a Study of Reaction to Frustration," Journal of Personality, Vol. 14, 1945, pp. 3-23.

[37] M. Barker and I. Burton, Differential Response to Stress in Natural and Social Environments: An Application of a Modified Rosenzweig Picture Frustration Test, Univ. of Toronto, Natural Hazard Research Working Paper, No. 5, 1969, p. 18.

[38] R. W. Kates, "International Research on Natural Hazards," Seminar presented to the Inter-Sessional Symposium, Univ. of Hawaii (Manoa Campus), Dept. of Geogr., January 6, 1971.

[39] Anonymous, Suggestions for Comparative Field Observations on Natural Hazards, Univ. of Toronto, Natural Hazard Research Working Paper No. 16, 1970, pp. 24 and 26.

> *the results into statistical aggregates. Without doubt formal interviewing succeeds in achieving higher reliability than informal techniques.*[40]

There is still a problem that results from the strictly formal interview, the comprehension of the questions. All answers will relate to the same thing only if the respondents interpret or have interpreted for them the questions as meaning one particular thing. Therefore, it is necessary to have a structured questionnaire but one must make allowances for the interviewer to attempt to relate the questions to the respondents, for it is only in this manner that the desired types of responses can be elicited. It was for this reason, also, that personal interviews were used, instead of mailed questionnaires. In mailed questionnaires spontaneous answers are not possible, "...each question can be studied by the respondent and a correct answer can be phrased. There is not the depth in penetration of the personal interview."[41]

The questionnaire was developed to test the hypothesis as well as to derive additional information that would indicate the knowledge of owner-residents of the government regulations that apply to natural and man-induced erosion in

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[40] C. A. Moser, Survey Methods in Social Investigation, Heinemann, London, 1963, p. 204.

[41] J. N. Jackson, Surveys for Town and Country Planning, Hutchinson University Library, London, 1963, p. 72.

Edmonton. The questionnaire was pre-tested twice to clear up all noticed ambiguities in the content and question construction, the final form appearing as Appendix A.

A total population sample was chosen as the best method to obtain the desired data. It was decided that only single family dwellings that were directly adjacent to the top of the river or ravine system would be considered. Only those homes where the owner is a resident (hence the name owner-resident) were used. The Assessment Department of the City of Edmonton consented to a survey being conducted of their property assessment records in order to determine the owners as well as the land and building assessments (See Appendix B which indicates how the City determines assessment values). Using the above criteria it was found that there were 197 owner-residents that could be considered in the study. A form letter stating the "academic nature" of the interview, as well as its voluntary nature, was sent to each owner-resident (Appendix C). A prepaid postcard was also placed in the letter (Appendix C). If the prospective respondent did not wish to participate he could check the appropriate box and return the card. If he chose to participate he could give his telephone number and the interviewer would call and make an appointment. The total response was nearly fifty per cent, of which two thirds were willing to be interviewed (Table I shows the complete returns).

After a period of six weeks a follow-up letter (Appendix C) was sent to those owner-residents who did not reply to the first letter, ten additional responses were elicited. Personal interviews were set up by appointment; in a few instances, at the request of the respondents, interviews were conducted on the telephone. A personal letter of appreciation was sent to each respondent a few days after the interview had been given.

Table I Sample Response

Response	Frequency
Affirmative	60
Refusals	22
Cancelled by Respondents	4
No longer property owners	2
Not available over the summer	3
Deceased	2
TOTAL RETURNS	93
No response to either letter	104
TOTAL POPULATION	197

At the completion of the data collection process each interview was coded and computer cards were punched in preparation for analysis of the data. Two different computer analyses were used. Absolute frequency was determined on most of the variables and several crosstabulations were completed.

V. SUMMARY

The remaining chapters of this study reflect the organization of the first chapter. The physical stimuli of the erosional hazard are investigated in the second chapter by looking at the geological formations and how these influence erosion, erosion's influence on the geomorphology is also studied. The soils, climate, and vegetation are examined in this chapter. The testing of the hypotheses (with the exception of the last secondary hypothesis which deals with technical adjustments) and the establishment of the characteristics and preferences of the sample population are given in the third chapter. The fourth chapter tests the last secondary hypothesis and also investigates the different types of adjustments (both technical and social). An examination of the statutes and bylaws that apply to natural and man-induced erosion is also included. The final chapter contains the implications and applications of the thesis as well as the conclusions.

CHAPTER 2

PHYSICAL GEOGRAPHY

The stratigraphy, soil, climate, and vegetation are factors in the problem of bank instability in the North Saskatchewan River Valley. It is necessary to investigate the influences of the physical geographic features on the causes of natural erosion. Skempton[1] felt that too much emphasis is placed on many of the physical geographical influences, such as lithology and seepage when determining why natural erosion occurs on a particular slope. He noted that the "simple rules" of an erosional cycle (i.e.: gravitational pull, undercutting, oversteepening of slope, and weathering) would be sufficient to account for all forms of natural slope erosion. But it has been shown (for example see Strahler,[2] Panyukov,[3] and Selby[4]) that these factors

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[1]A. W. Skempton, "Soil Mechanics in Relation to Geology," Proceedings, Yorkshire Geological Society, Vol. 29, Part 1, No. 3, April 27, 1953, p. 51.

[2]A. N. Strahler, "Equilibrium Theory of Erosional Slopes Approached by Frequency Distribution Analysis," American Journal of Science, Vol. 248, 1950, pp. 673-696 and pp. 800-814.

[3]P. N. Panyukov, "The Classification and Characteristics of Physico-Geologic Phenomena," The Stability of Slopes, I. V. Popov and F. V. Kotlov (Editors), Soviet Academy of Science Press, Moscow, U.S.S.R., 1961, pp. 5-8.

[4]M. J. Selby, Slopes and Slope Processes, Waikato Branch, New Zealand Geographical Society, Publication No. 1, 1970, 59 pp.

plus many other variables contribute to slope failure. It is incorrect to label one particular variable as the cause for starting natural erosion though, in many cases, it may have been the triggering factor.[5]

I. STRATIGRAPHIC DIVISIONS OF THE EDMONTON DISTRICT

There are four major and one minor stratigraphic divisions in the Edmonton District. The bedrock is the (A) Upper Cretaceous Edmonton Formation, it is in this stratigraphic division that the major problems of slope failure occur. The remaining four divisions are usually subsequent to the major problems of slope failure, but are themselves susceptible to minor movements. In certain localities, overlying the Edmonton formation there are (B) the pre-glacial Pleistocene Saskatchewan gravels and sands. In most areas the sands overlie a thin veneer of gravel but it has also been found to lie directly upon the bedrock. Unconformably overlying the Saskatchewan gravels and sands, and in some places where neither is present, the bedrock, is (C) a Wisconsin Age glacial till. The till is overlain by (D) a thin mantle of lacustrine deposits of Pro-Glacial Lake Edmonton. The minor stratigraphic division is (E) the post-Lake Edmonton alluvial and aeolian deposits.

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[5] D. J. Varnes, "Landslide Types and Processes," Landslides and Engineering Practices, National Academy of Science, National Research Council, Washington, D.C., Publication No. 554, 1958, p. 42.

A. Edmonton Formation

The Edmonton Formation is a fresh water deposited sedimentary rock of Upper Cretaceous age. It is composed of soft, grey to white weathered, bentonitic, feldspathic sandstones and friable, bentonitic, silty, grey to brown shales. Beds of tuff, coal, pink shales, and nodular ironstone are associated with it.[6] It contains abundant tree and saurian fossils.

The true thickness of the Formation can only be hypothesized. Williams and Dyer[7] estimated it to be 1000 feet thick on the Red Deer River, which is about 100 miles south of the City. Andrichuk,[8] using oil well records, said that the Edmonton Formation is 750 feet thick at Leduc, just south of the City. Farvolden[9] estimated it to be approximately 800 feet thick at the town of Devon, which

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[6] R. A. McGrossan and R. P. Glaister (Editors), Geological History of Western Canada, Alberta Society of Petroleum Geologists, Calgary, 1966, p. 178.

[7] M. Y. Williams and W. S. Dyer, Geology of Southern Alberta and Southwestern Saskatchewan, Geological Survey of Canada, Memoir No. 163, 1930, p. 47.

[8] J. M. Andrichuk, Stratigraphy of an Area Including Majeau Lake No. 1 Well, Edmonton, Alberta, Dept. of Geol., Univ. of Alberta, Unpublished M.Sc. Thesis, 1949, p. 67.

[9] R. N. Farvolden, "Rate of Groundwater Recharge Near Devon, Alberta," in Early Contributions to the Groundwater Hydrology of Alberta, R. N. Farvolden, et. al. Research Council of Alberta, Bulletin No. 12, 1963, p. 100.

is west of Leduc. The dip of the bedrock is between seventeen and twenty feet per mile to the southwest,[10] from the above data this would indicate that the Formation's thickness is equal to or less than that at Leduc.

Byrne[11] and Ritchie[12] divided the Edmonton Formation into three sections, the lower and upper sections being composed of shales and sandstones while the middle section is a volcanic ash, the Kneehills Tuff. Volcanic activity occurred to the west of the region throughout the Upper Cretaceous Period blanketing the area with volcanic ash, which is today, present as highly plastic bentonitic shales, bentonitic sandstones, and beds of pure bentonite.[13] The major clay mineral present in the Edmonton Formation is calcium montmorillonite.[14] Montmorillonite minerals and their swelling capacity have been well documented (see Holtz[15]). It has

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[10] L. A. Bayrock and T. E. Berg, Geology of the City of Edmonton, Part 1: Central Edmonton, Research Council of Alberta, Report 66-1, 1966, p. 3.

[11] P. J. S. Byrne, Sediments Associated with the Kneehills Tuff in the Edmonton Area, Dept. of Geol., Univ. of Alberta, Unpublished M.Sc. Thesis, 1951, 67 pp.

[12] W. D. Ritchie, The Kneehills Tuff, Dept. of Geol., Univ. of Alberta, Unpublished M.Sc. Thesis, 1957, 66 pp.

[13] W. R. Maiklem and F. A. Campbell, "A Study of the Clays from Upper Cretaceous Bentonites and Shales in Alberta," Canadian Mineralogist, Vol. 8, Part 3, 1965, p. 354.

[14] S. Thomson, Professor of Civil Engineering, Univ. of Alberta, Pers. comm., September 22, 1970.

[15] W. G. Holtz "Expansive Clays - Properties and Problems," Quarterly, Colorado School of Mines, Vol. 54, No. 4, October, 1959, pp. 89-125.

been found that when water is available montmorillonite absorbs it and swells and becomes incompetent. Though true bentonite is formed by the alteration of volcanic ash, in situ, and is composed of the mineral montmorillonite, the term is applied to other montmorillonite clays of non-volcanic origin.[16]

The Edmonton Formation was over-consolidated by the formation of ice and glacial deposits, and possible by as much as 200 feet of sedimentary Paleocene deposits (Paskapoo Formation),[17] though none of the latter appear in the present stratigraphy of the study area. The glacial ice and incorporated load are estimated to have been about 5,000 feet in depth.[18] Local asymmetric folds were formed by the overriding of the glacier in what is normally a horizontal-

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[16] R. E. Grim, Applied Clay Mineralogy, McGraw-Hill, New York, 1962, 422 pp. Throughout the remainder of this report the term bentonite will be used in referring to all clays and shales of montmorillonite matrix.

[17] S. Thomson, "Riverbank Stability Study at the University of Alberta, Edmonton," Canadian Geotechnical Journal, Vol. 7, No. 2, 1970, p. 159.

[18] L. A. Bayrock and G. M. Hughes, Surficial Geology - Edmonton District, Research Council of Alberta, Preliminary Report 62-6, 1962, p. 28.

ly bedded formation.[19]

The bedrock topography indicates that before glaciation the Edmonton District consisted of broad valleys separated by low broad divides and that the drainage was dendritic.[20] The present North Saskatchewan River Valley is post-glacial, cutting through the pre-glacial bedrock valleys and stream divides in the study area. The banks of the present river are steep, in some cases approaching 90°, while an angle of 1.5° is rarely exceeded on the slopes of pre-glacial valleys. Often the latter had a width of several miles while that of the present river valley rarely exceeds one mile.[21]

B. Saskatchewan Gravels and Sands

Rutherford[22] was the first to use the name

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[19] G. R. Pearson, The Clover Bar Coal Zone, Edmonton-Morinville District, Alberta, Research Council of Alberta, Preliminary Report 61-1, 1961, 26 pp. and J. A. Westgate, "The Quaternary Geology of the Edmonton Area, Alberta," in Pedology and Quaternary Research, S. Pawluk (Editor), National Research Council of Alberta, Special Publication, 1971, pp. 129-151.

[20] V. A. Carlson, Bedrock Topography and Surficial Aquifers of the Edmonton District, Alberta, Research Council of Alberta, Report 66-3, 1967, p. 1.

[21] Ibid., p. 8.

[22] R. L. Rutherford, "Saskatchewan Gravels and Sands in Central Alberta," Transcripts, Royal Society of Canada, 3rd Series, Vol. 31, Sec. 4, 1936, pp. 81-95.

Saskatchewan gravels and sands for the pre-glacial Pleistocene deposits which overlie the Edmonton Formation. In the Edmonton District these deposits consist of a coarse gravel overlaid by a fine consolidated sand. Up to four per cent of the gravel originated from local bedrock while the remainder was either eroded from the Paleocene Paskapoo Formation or was transported from the Rocky Mountain Cordillera.[23] Due to glacial erosion and topographic bed-rock highs, Saskatchewan gravels and sands are not found in all localities. Roed[24] found no Saskatchewan deposits in an area adjacent to the University of Alberta campus, and there is, in some sections of southwestern Edmonton and near Devon, an absence of gravel deposits.[25] The gravels and sands are considered to be of Pleistocene age but older than the "Classical Wisconsin Ice Age." This has been determined through correlation of pre-Wisconsin mammal remains.[26]

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[23] A. MacS. Stalker, Surficial Geology of Blood Indian Reserve, No. 148, Alberta, Geological Survey of America, Paper 63-25, 1963, p. 3.

[24] M. A. Roed, River Bank Stability Study, University of Alberta, Edmonton, Alberta. (Appendix I), Dept. of Geol., University of Alberta, Unpublished manuscript, 1966, 42 pp.

[25] Carlson, op. cit., footnote 20.

[26] T. H. F. Reimchen, Pleistocene Mammals from the Saskatchewan Gravels in Alberta, Canada, Dept. of Geol., University of Alberta, Unpublished M.Sc. Thesis, 1968, 92 pp.

C. Wisconsin Age Glacial Till

At present no stratigraphic evidence exists indicating earlier glaciation than that which occurred during the Wisconsin Advance. Gravenor and Ellwood[27] dated the earliest till as 21,600±900 years B.P., but Westgate and Bayrock[28] determined that a date of 31,000 years B.P. would best indicate the commencement of glaciation in the Edmonton District.

There is an average depth of twenty-five feet of till lying on the pre-glacial topography, but in pre-glacial valleys there may be depths up to 200 feet. Local bedrock forms from 73 to 90 per cent of the glacial till.[29] The susceptibility of glacial deposits to erosion is reviewed, below, in section F.

D. Pro-Glacial Lake Edmonton Deposits

The relatively flat topography of the Edmonton District can be attributed to the post glacial filling of

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[27] C. P. Gravenor and R. B. Ellwood, A Radiocarbon Date For Smoky Lake, Alberta, Research Council of Alberta, Preliminary Report 56-3, 1956, 17 pp.

[28] J. A. Westgate and L. A. Bayrock, "Periglacial Structures in the Saskatchewan Gravels and Sands of Central Alberta," Journal of Geology, Vol. 72, No. 5, 1964, p. 643.

[29] Stalker, op cit., footnote 23, p. 4.

the irregularities in the pre-existing surface with lacustrine deposits. These were laid down at the close of the Wisconsin Ice Age, in a large pro-glacial lake, known as Lake Edmonton. It has been postulated by Hughes[30] that Lake Edmonton existed for 80 years. Downwasting of the ice dam opened lower outlets to the east and northeast. Eventually, with the complete removal of the ice mass, the Pleistocene Proto-North Saskatchewan River was able to drain the lake. Westgate postulates this to have happened prior to 12,500 years B.P.[31]

Hill[32] noted that the lacustrine deposits consisted of silt and clay. The mechanical analyses of the Lake Edmonton deposits revealed that five per cent were sand, 40 per cent silt, and 55 per cent clay, reaching a maximum thickness of between 50 and 100 feet. The clay contained a high proportion of calcium montmorillonite.[33] See section F, below, for the influences that the Lake Edmonton deposits have on natural erosion.

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[30] G. M. Hughes, A Study of Pleistocene Lake Edmonton and Associated Deposits, Dept. of Geol., Univ. of Alberta, Unpublished M.Sc. Thesis, 1958, 60 pp.

[31] Westgate, op. cit., footnote 19, p. 150.

[32] E. L. Hill, Lacustrine Clay of the Edmonton Region, Dept. of Geol., Univ. of Alberta (Strathcona), Unpublished M. Sc. Thesis, 1911, 17 pp.

[33] Bayrock and Berg, op. cit., footnote 10, pp. 10-11.

E. Post Lake Edmonton Deposits

Following the final draining of pro-glacial Lake Edmonton the drainage in the Edmonton District continued to flow to the northeast but in no definite channel. Sand dunes were formed in the Devon area from fluvial-lacustrine sands that were, in many cases, derived from the very shallow meandering channels that existed before the incisement of the North Saskatchewan River, the sand dunes becoming stabilized prior to the river's incision.[34]

Westgate[35] suggests that the initial, and by far the greatest, degradation of the present North Saskatchewan River Valley occurred between 12,500 and 11,500 years B.P. The river has not been in a continual degradation cycle since its inception. Radiocarbon dates have been determined on postglacial alluviums in the Edmonton District that indicate there have been two periods of net aggradation; these occurring between 11,500 and 10,000 years B.P. and between 8,500 and 4,000 years B.P.[36]

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[34] Hughes, op. cit., footnote 30, p. 35.

[35] Westgate, op. cit., footnote 19, p. 150.

[36] R. B. Rains, Some Aspects of the Fluvial Geomorphology of the Whitemud Basin, Central Alberta, Dept. of Geogr., Univ. of Alberta, Unpublished PhD Thesis, 1969, p. 205.

F. Influences of the Stratigraphy on Natural Erosion

The bentonitic composition of the bedrock is a major factor which gives rise to natural erosion in the Edmonton area. Peterson[37] found that the bentonitic shales of Western Canada suffered from elastic rebound which not only moves upwards but also outwards, especially when allowed to by the presence of river valleys. The release of rebound outwards may substantially weaken the shale producing incompetent material. "If the ultimate equilibrium strength of the clay (shale) is less than that required to sustain the stability of the slopes as cut, a slip will occur."[38] This rebound is still active and causes extensive networks of cracks and fissures near the North Saskatchewan River Valley.[39] Peterson has demonstrated that the horizontal pressure in the clay shales is approximately 150 per cent of the vertical pressure.[40] Christiansen's[41] hypothesis

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[37] R. Peterson, "Rebound in the Bearpaw Shale, Western Canada," Bull., Geol. Soc. of America, Vol. 69, 1958, p. 1113.

[38] W. H. Ward, "The Stability of Natural Slopes," Geogr. Journ., Vol. 105, Nos. 3 & 4, 1945, p. 185.

[39] H. E. R. Ottley, Swelling Properties of Expansive Clays, Dept. of Civil Engineering, Univ. of Alberta, Unpublished M.Sc. Thesis, 1962, p. 1.

[40] Peterson, op. cit., footnote 37, p. 1118.

[41] E. A. Christiansen, Glacial Geology of the Swift Current Area, Saskatchewan, Saskatchewan Dept. of Mineral Resources, Report No. 32, 1959, 62 pp.

for the origin of slope failure in such deposits in Saskatchewan is:

> *When downcutting by the stream penetrates the drift-bedrock contact, the confining pressure is reduced sufficiently to cause the plastic shales to move laterally into the stream valley. The movement of the shale places the overlying competent drift in a state of tension, and fractures are formed. The fractures greatly reduce the internal shear resistance within the drift, and as a result of this weakening, slope failure occurs.*[42]

Hardy[43] described a similar process that occurred on Grierson Hill in the City of Edmonton.

As has been stated above, the major mineral contained in bentonite is expanding montmorillonite. Holtz[44] has shown that "...if loads are reduced, as by excavation, on a saturated expansive clay, the clay will adsorb additional water and expansion will occur until a balance of forces is obtained." It has been noted that montmorillonite shales have such low strength that they form slippages on inclines as low as five degrees from the horizontal.[45] But through

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[42] Ibid., pp. 22-23.

[43] R. M. Hardy and Associates, Second Report, Re: Grierson Hill, Edmonton, Alberta, to the City of Edmonton, Engineering Department, Unpublished Report, March 15, 1957, p. 6.

[44] Holtz, op. cit., footnote 15, p. 95.

[45] F. B. Leighton, "Landslides and Hillside Development," Engineering Geology in Southern California, Association of Engineering Geologists, Los Angeles, 1966, p. 161.

continual erosion of the banks the balance of forces may only be reached for a short period. Birot[46] noted that water saturation will cause an upward hydrostatic pressure to be created within a horizon which in turn affects its stability. The water, which is to be adsorbed by the montmorillonite, is transported in many ways. Hardy[47] found that the source of water that was causing movement of Grierson Hill, in Edmonton, was "...several comparatively thin water bearing strata in the undisturbed material above the slide area."[48] The bedrock has a dip of 20 feet per mile to the southwest, the water in the strata tends to flow in that direction, unless it is interupted by an obstruction - such as the river valley. Here the water builds up a considerable hydrostatic head, water (under pressure) seeps into the surrounding bentonitic beds from the aquifer, the clay expands and, subsequently, there is movement.[49] Both Hardy[50] and Beach[51]

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[46] P. Birot, The Cycle of Erosion in Different Climates, Univ. of California Press, Berkeley, 1968, p. 32.

[47] R. M. Hardy and Associates, Report Re: Grierson Hill, Edmonton, Alberta, to the City of Edmonton, Engineering Dept., 1953, 5 pp.

[48] Ibid., p. 5.

[49] Panyukov, op. cit., footnote 3, and Selby, op. cit., footnote 4.

[50] Hardy and Associates, op. cit., footnote 43, p. 7.

[51] H. H. Beach, The Geology of the Coal Seams of Edmonton and District and a History of Its Mining, Dept. of Geol., Univ. of Alberta, Unpublished M.Sc. Thesis, 1934, Appendix I.

found free-flowing water in the coal beds in the Edmonton Formation.

Another source of water is that which runs in the pre-glacial valleys. The Saskatchewan gravels and sands are excellent aquifers. The bedrock thalwegs (the line which joins the deepest points of the valley's channel) cause subsurface drainage to move in a general northerly direction (see Figure 2) in the study area, though it has been observed that springs in pre-glacial thalwegs occur and flow to the south. Hodges[52] feels that the Saskatchewan sands under Windsor Park, adjacent to the University of Alberta campus, are one of the most substantial aquifers in the City. This zone of water causes many of the active movements in this area. Meyboom[53] observed in a similar geological situation that the bedrock often turned "...into a thick slurry, partly because of the destruction of the clay molecules which cause adsorbed water to be released and partly because of the presence of free water that is discharged from the outcropping sand lenses." The resulting slurry is transformed into a mudflow.

It was found in the study area that the Saskatchewan gravels and sands remain competent if the angle of slope

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[52] G. Hodges, Assistant Roadways Engineer, City of Edmonton, Pers. comm., June 6, 1967.

[53] P. Meyboom, Groundwater Resources of the City of Calgary and Vicinity, Research Council of Alberta, Bull. No. 8, 1961, p. 68.

does not increase beyond 35°. Hardy, et.al.,[54] found that in the University area the sands would collapse if undercutting or overburden caused the angle of repose to increase above a 30° to 40° angle. Therefore it is reasonable to assume that the Saskatchewan gravels and sands are not active triggering factors of slope failure but are directly affected by mass movement in the bedrock or disturbance from above, though the water providing lubrication or energy for slope failure may have been transported through them.

As Christiansen[55] has shown, the glacial drift is not an active participant in slope failure but rather becomes incompetent only after the bedrock has collapsed. As has been noted, the glacial till is composed of 73 to 90 per cent of local bedrock, it would seem likely that this factor alone would cause the till to react in like manner and form as the bedrock, but this seems to be untrue. Throughout the study area the glacial tills remain competent, relatively speaking, and highly compacted. Rock falls occur only in areas where the underlying support, the Saskatchewan gravels and sands, or the bedrock, has been displaced.

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[54] R. M. Hardy, et. al., Report on River Bank Stability, University of Alberta, Edmonton, Alberta, Unpublished Report submitted to the Alberta Dept. of Public Works, July, 1967, p. 16.

[55] Christiansen, op. cit., footnote 41, p. 23.

In conclusion it can be said that lithological considerations play a most important role in producing slope failure along the North Saskatchewan River. From the initial incision, to the present, stream erosion has caused some of the mass movement along the valley, and has been the triggering force for starting the cycle of erosion. Thomson[56] noted that during a recorded period from 1882 to 1965, the river bank adjacent to the University of Alberta campus was eroded from 42 feet to 100 feet; the average rate being 0.5 feet per year. However, "...it is possible that this erosion was not uniform year to year. Most likely several feet occur rapidly as a result of banks undergoing landslides and the resulting material being carried away. In the intervening years erosion is much less."[57] Yatsu[58] best sums up the bentonitic effects on river slopes:

> *If the bedrock contains some components of swelling minerals, it swells with pressure when afforded with water and is apt to become unsolidified clayey debris. Such clayey debris is easily affected by mass movement... Moreover, from microscopical points of view, when water is available localized stresses will occur in and around swelling clay minerals and interstratified clay minerals in which some element has swelling characteristics. These unevenly distributed stresses will destroy the*

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[56] Thomson, op. cit., footnote 41, p.162.

[57] Ibid.

[58] E. Yatsu, "Some Problems on Mass Movement," Geografiska Annaler, Vol. 49, Series A, Nos. 2-4, 1967, pp. 396-401.

> *tightly packed structure of clayey beds that must be responsible for their strength.*[59]

II. SOILS

"Glacial till is by far the most significant parent material from which Alberta soils develop."[60] Soils within the urban area have not been classified, though Proudfoot[61] did classify those in the valley for Edmonton while Bowser, Kjearsgaard, Peters, and Wells[62] classified those of the surrounding district.

The valley walls are unclassified. This is because of the lack of development of soil profiles due to natural erosion, freeze and thaw cycles, and soil wash, which remove developing soils before they can accumulate. The soil classification (Table II) on the plains is interpolated from Bowser et al., it is of the Chernozemic order and is composed of four soil series: the Malmo silty clay loam, the

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[59] Ibid., pp. 399-400.

[60] S. Pawluk and L. A. Bayrock, Some Characteristics and Physical Properties of Alberta Tills, Research Council of Alberta, Bull. No. 26, 1969, p. 1.

[61] J. A. Proudfoot, Some Aspects of the Recreational Geography of the North Saskatchewan River Valley. Dept. of Geogr., Univ. of Alberta, Unpublished M.A. Thesis, 1965, 90 pp.

[62] W. E. Bowser, A. A. Kjearsgaard, T. W. Peters, and R. E. Wells, Soil Survey of Edmonton Sheet (83H), Canada, Dept. of Agriculture, Alberta Soil Survey Report No. 21, 1962, 66 pp.

TABLE II

SOIL CLASSIFICATION

(after Bowser, et al, 1962)

ORDER	SOIL SERIES	DESCRIPTION (quoted from Bowser, et al, 1962)
Chernozemic	Malmo Silty Clay Loam	"...a fairly well to well drained eluviated black soil developed on slightly saline lacustrine materials. These soils are usually found in slightly basin-like areas, actually post-glacial laking basins." pp. 29-30
	Peace Hills Fine Sandy Loam	"...well to excessively drained orthic black soil of coarse texture developed on alluvial aeolian parent material. Under native conditions these soils support some tree growth and considerable shrub growth." p. 26
	Ponoka Loam	"...well drained weakly eluviated black soils developed on alluvial lacustrine, medium textured materials. This soil is often found on the edge of basin-like areas; that is, on the edge of lacustrine basins." p. 29
	Mico Silt Loam	"...well drained orthic black dark grey soil developed on lacustrine material. In general, the Mico soils occur near the edge of the lacustrine basin, Malmo may occur towards the center." p. 31

- continued

TABLE II, continued

ORDER	SOIL SERIES	DESCRIPTION
Podzolic	Leith Fine Sandy Loam	"These coarse textured soils are well drained dark grey wooded and have developed on alluvial aeolian parent material." p. 45
Regosolic	Alluvium and Alluvium Sandy Loam	" The soils occur along the lower terraces of the river valleys. Many have received considerable alluvium within the last century. Although there is considerable variation in texture, in general they are loams, silt loams, and very fine sandy loams." p. 49

Peace Hills fine sandy loam, the Ponoka loam, and the Mico silt loam. In the river valley itself, disregarding the valley walls as aforementioned, the soils are almost entirely of the Regosolic alluvium and alluvial sandy loam. There are two small sections of the Chernozemic and Podzolic orders present in the North Saskatchewan River Valley. The Peace Hills fine sandy loam is the soil series of the Chernozemic order while the Leith fine sandy loam is the Podzol.

The importance of the soil in the erosional hazard is its high clay content. When this becomes saturated, it is unstable and may develop into a mudflow. Artificial soil, that is to say fill that is not endemic to the site, is often placed on the valley slopes and does not have proper adhesion to the slopes. Saturation of the fill as well as improper compaction can result in the collapse of this soil. In the fourth chapter there is a discussion of soil saturation problems.

In most cases soil erodibility is determined by vegetation cover, which will be covered in Section IV.

III. CLIMATE

The climate and general weather pattern in the Edmonton Region has a direct influence on slope failure. For it is often found that during periods of high preci-

pitation the amount of erosion increases, the temperature will determine if the precipitation will be adsorbed into the groundwater system or runoff.

The climate of Edmonton is best described in the Annual Meteorological Summary of 1969[63] as:

> *Edmonton, at 53°35' N, is the most northerly city of its size in Canada. Its protected position in the lee of the Rocky Mountains gives an annual average precipitation of only 18.64 inches. However, 65% of this falls during the growing season of spring and summer, and this supplies sufficient moisture for successful farming.*
>
> *The climate is described as a cold, temperate climate, but it is not so severe as might be expected in a continental climate at 53°N. The chinooks, which modify the long winter just east of the Rockies do not usually reach as far as Edmonton. However, their modifying influence does extend to Edmonton for brief spells nearly every winter.*
>
> *The average winter temperature is 10.4°F. Low temperatures of -30°F occur on the average of three or four times each winter. Extremely low temperatures, -40°F or less occurred about once every second winter up till 1950, but since that time the heating effect of the city has prevented temperatures from dropping that low.*[64]

The river valley, itself, must be taken as a microclimatic region in the Edmonton District. The slope aspect

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[63] Canada, Dept. of Transport, Meteorological Branch, Annual Meteorological Summary 1969, Edmonton, Alberta, Long Term Records 1881-1969, 40 pp.

[64] Ibid., pp. 1-2.

of the riverbank produces microclimatic areas within the valley. "Slope climate...is determined, in the first place, by the different amounts of direct solar radiation and heat received by an inclined surface as compared with a horizontal surface."[65] South facing slopes receive the sun's insolation at a more direct angle and for longer periods than the north facing slopes, the highest temperatures being found on the south-west slopes. This causes frost to melt and retards its formation allowing greater adsorption of water into the soil and underlying strata, as well as permitting a high evapotranspiration rate. Greenland[66] showed this to be especially significant on southwest slopes (correlated from his work in the Southern hemisphere). The north and east facing slopes either receive less insolation or receive it earlier in the day. Therefore, these slopes are cooler and wetter. The frost remains in the soil longer allowing better soil formation and a higher vegetation density.[67]

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[65] R. Geiger, The Climate Near the Ground, Harvard Univ. Press, Mass., 1966, p. 370.

[66] D. E. Greenland, Solar Radiation Studies at Cass in the Southern Alps (New Zealand), Australia-New Zealand Association for Advancement of Science, 41st Congress, Adelaide, August, 1969, 13 pp.

[67] M. A. Melton, "Intravalley Variation in Slope Angles Related to Microclimatic and Erosional Environment," Bull., Geol. Soc. of America, Vol. 71, 1960, p. 134.

Crozier[68] found that movements of the slope could be directly related to rainfall. It was found that during periods of maximum ground moisture the slopes were more sensitive to slope failure. The maximum period of rainfall in the Edmonton District is during spring and summer, during spring the valley walls are also receiving large amounts of melt water as the frost moves out of the ground. These two factors contribute to giving the valley walls excessive amounts of moisture, most of which percolates down into pre-glacial thalwegs and henceforth comes in contact with the bedrock. Hardy[69] reported that three inches of rainfall had fallen on Grierson Hill in Edmonton within two days, during the fall of 1958, "...about a week later some surface cracks developed which indicated movement of practically the whole slide area. The location and extent of the surface cracking indicated a deep-seated movement."[70] Rapid erosion of the riverbank is "...especially prevalent at times of abnormal high precipitation."[71] In late June, 1965, Edmonton received four inches of rain in a two day period, a small landslide

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[68] M. J. Crozier, "Earthflows and Related Environmental Factors of Eastern Otago," Journal of Hydrology (New Zealand), Vol. 7, No. 1, 1968, pp. 4-12.

[69] R. M. Hardy, Letter to the City Engineer, City of Edmonton, concerning movement on Grierson Hill, October 7, 1958, 4 pp.

[70] Ibid., p. 3.

[71] Roed, op. cit., footnote 24, p. 25.

developed on July 3rd on the bank adjacent to the University of Alberta campus and measured seven feet across. By early September the surface area of the slide had expanded to a width of 41.5 feet.[72]

As Geiger[73] has shown, the southwest slope receives maximum amounts of insolation. Therefore it can be said that these "...slopes would dry out much more rapidly, and to a greater extent between rainstorms, than any other slope thus causing concomitant volume changes within the soil blocks. Volume change of this scale would cause a greater reduction of cohesion along soil joints on (southwest) slopes than any other slope aspect."[74] This allows hydration to reach greater depths when water is next available to the slope. Prior and Ho[75] found that bentonitic slope failures could be influenced by climatic factors, especially hydration or dehydration. They noted in areas where moisture was prevented from reaching the bentonite, because of snow cover or frost, this lack of hydration imparted "...a seasonality to the landslide activity."[76] It has

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[72] Ibid.

[73] Geiger, op. cit., footnote 65.

[74] M. J. Crozier, Mass Movement in Eastern Otago, Dept. of Geogr., Univ. of Otago (New Zealand), Unpublished PhD Thesis, 1970, p. 63.

[75] D. B. Prior and C. Ho, "Bentonitic Landslides," Science, Vol. 167, February 13, 1970, pp. 1014-1015.

[76] Ibid., p. 1015.

been noted, in the North Saskatchewan River Valley, that all aspects of slope are subject to mass movement.

IV. VEGETATION

Schumm[77] has said that vegetation can be a factor in slope erosion by either its presence or absence. In a humid microclimatic location (north facing) the vegetation aids infiltration which promotes movements in the valley sides through hydration; a dry microclimate (south facing) produces sparse vegetation which allows precipitation to runoff and will cause steep parallel retreating slopes (if adequate erosional forces are present at the base of the slope to transport the debris that is brought downslope). Gravenor, Green, and Godfrey[78] noted that mass movement takes place in Alberta on the heavily vegetated slopes of valleys, they implied that this was due to the presence of excessive water found in these vegetated zones.

Edmonton's sub-humid continental climate is conducive to the development of grasslands with light aspen

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[77] S. A. Schumm, "Evolution of Drainage Systems and Slopes in Badlands at Perth, Amboy, New Jersey," Bull., Geol. Soc. of America, Vol. 67, 1956, pp. 597-646.

[78] C. P. Gravenor, R. Green, and J. D. Godfrey. Air Photographs of Alberta, Research Council of Alberta, Bull. No. 5, 1960, 38 pp.

forests.[79] But, due to the microclimatic factors such as the amount of radiation and retention of moisture there are significant contrasts in vegetative cover on the valley banks. Bird[80] placed the Edmonton District in the ecological classification of an aspen poplar community.

As was previously stated, the microclimate of the north facing and south facing (as well as the east and west facing) slopes have a measurable contrast to each other, it follows that the vegetative cover of these slopes also will be different. In the City of Edmonton, it was noted that in the main valley of the North Saskatchewan River the north facing slopes "...are heavily wooded with few exceptions."[81] Visher[82] found that south facing slopes, in temperate zones, tend to support grasslands, due to soil heaving.

> *This is because soil heaving, caused by the formation of ice crystals, often renders the top layer (of the soil) fluffy after the thaw, and easily eroded. The breaking of*

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[79] F. A. Wyatt, A. S. Wood, and J. D. Newton, "Nitrate Production Under Field Conditions in Soils of Central Alberta," Scientific Agriculture, Vol. 17, September 1926, pp. 10-19.

[80] R. D. Bird, Ecology of the Aspen Parkland of Western Canada, in Relation to Land Use, Canada, Dept. of Agriculture,Research Branch Publication No.1066, 1951, 155 pp.

[81] Proudfoot, op. cit., footnote 61, page 35.

[82] S. S. Visher, "Climate and Geomorphology," Journal of Geomorphology, Vol. 4, 1940, pp. 54-64.

> *many small shallow roots by the heaving is also significant; sometimes it locally kills what had previously been a good stand of grass or small trees...*[83]

In Edmonton, when comparing north facing slopes, "...those facing south are usually grass and shrub covered."[84] Though this may be a reflection of man's activities on these slopes, the north side of the river having been settled and developed first. Vegetation has been interpreted as an indicator of downslope movement.[85] It will be seen in the third chapter that some respondents have noted that vegetation is a prime indicator of erosion. Curved tree trunks may be a common indicator of slope failure, the tree trunks are often pushed to an angle near the perpendicular (to the horizontal plane), through the process of heliotropy the upper trunk attempts to return to a vertical position which produces a curved trunk. Parizek and Woodruff[86] have cautioned that slope movement with resulting heliotropy may not be the only cause of curved trunks, many deformations can be "...related to mechanical and physiological causes."

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[83]Ibid., p. 61.

[84]Proudfoot, op. cit., footnote 61, p. 35.

[85]R. L. Ives, "Vegetative Indicators of Solifluction," Journal of Geomorphology, Vol. 4, 1940, p. 131.

[86]E. J. Parizek and J. F. Woodruff, "Mass Wasting and the Deformation of Trees," American Journal of Science, Vol. 255, No. 1, 1957, p. 69.

There is no doubt that the roots of trees, shrubs, and grasses do prevent soil wash and other minute erosive problems. The planting of shrubs on ravine and valley sides has been accepted as an adjustment in government and private sectors (see Chapter 4). Painter[87] found that though the vegetation was heavy along the North Saskatchewan River near LeSueur, it "...contributed nothing to the stability and (tree) roots were easily snapped off as the movement (the LeSueur block glide) took place." There are several further examples within the City which definitely attest to the vegetation cover being unable to prevent erosion (see Plates 2, 3, 5, and 11).

V. CONCLUSION

Natural erosion along the North Saskatchewan River in Edmonton is a continuing process, the river is incised into a weak, unstable, bentonitic bedrock. The valley sides retreat, naturally, at a small rate when there is active river erosion at the base of the slope. A delicate equilibrium exists on the valley slopes between the angle of repose, climate, and vegetation. If one is upset by nature or man the bank becomes unstable and erosion occurs. The

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[87] W. T. Painter, An Investigation of the LeSueur Landslide, Edmonton, Alberta, Dept. of Civil Engineering, Univ. of Alberta, Unpublished M.Sc. Thesis, 1964, p. 4.

thalwegs of the pre-glacial topography, which are infilled with Saskatchewan gravels and sands, provide drainage for groundwater which prevents emergence of seepage springs over many areas in the river valley. Where seepage springs are present small slides may occur.[88] The soil, derived from the clayey till, will turn into a slurry if too much water is allowed to accumulate in it. The addition of unseasonal amounts of water, whether through precipitation or through man's carelessness, can produce small erosional features, which "...are very likely to precipitate a major landslide."[89]

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[88] Thomson, _op. cit._, footnote 17, p. 23.

[89] Ibid., p. 167.

CHAPTER 3

POPULATION: CHARACTERISTICS, PREFERENCES AND PERCEPTIONS

I. INTRODUCTION

Before delving into the perceptions of owner-residents it is necessary to establish the characteristics of the population under study. Each area of the City which borders the river valley and ravines is ranked according to the average tax assessment of the property and buildings; the socio-economic factors of the population are illustrated; and preferences of the population (where they prefer to live as well as the advantages and disadvantages of the site) are given.

In Chapter I the major hypothesis stated that people perceive the hazard when they establish their domicile along the top of the river valley. Through computer crosstabulations and significance tests it is here tested. The education level in relation to perception as well as the assessment value as related to perception are also investigated. A weak correlation has

been determined, in a flood hazard study,[1] which indicates the older a person is the more pessimistic he becomes about the possibility of a higher frequency of occurrence of the hazard. This correlation is given as the third secondary hypothesis introduced in the first chapter. The awareness of the sample population to the erosional hazard was further examined by determining if the home-owners knew if other sections of the City had suffered damages from erosion, awareness was also investigated by determining if they knew of any indicators that would inform them that some type of erosion was about to occur.

II. POPULATION CHARACTERISTICS AND PREFERENCES

The residential districts adjoining the North Saskatchewan River Valley have been divided into nineteen areas (see Figure 2). Each area was named either after the major street, the ravine which it abuts, or the name for that certain section of the City as established by common usage. In three of these areas residents did not answer either the first or second letter asking for an interview. Because of this lack of information it is only possible to imply results that have been taken from other

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[1]W. Roder, "Attitudes and Knowledge on the Topeka Flood Plain," Papers on Flood Problems, G. F. White (Editor), Univ. of Chicago, Dept. of Geogr. Research Paper No. 70, 1961, pp. 62-83.

areas of equal ranking.[2]

Five rankings were determined for the study area (Table III). These were based on the arithmetic mean of the tax assessment of the property and house for each area (Table IV). It was decided that the assessment

TABLE III RANKING BY ASSESSMENT VALUE

Rank	Assessed Value (in Dollars)	Areas (see Fig.2)
I	Less than 5,000	9, 16
II	5,001 to 10,000	4, 8, 10, 14, 15, 17
III	10,001 to 15,000	12, 13
IV	15,001 to 20,000	1, 2, 3, 5, 6, 7, 18
V	More than 20,001	11, 19

TABLE IV

ARITHMETIC MEAN OF ASSESSMENT VALUE FOR EACH AREA

Source: Assessment Department, City of Edmonton, February 1971

1.	Valley View	$17,660.67	12.	Gold Bar	10,570.00
2.	Rio Terrace	15,510.52	13.	Rowland West	10,985.76
3.	Quesnell Crescent	19,734.00	14.	Rowland Capilano	9,636.36
4.	McKenzie Ravine	9,956.67	15.	Queen Elizabeth Park	8,480.00
5.	Riverside Crescent	19,053.33	16.	Connors Hill	4,587.27
6.	Summit Point	18,477.00	17.	Strathearn	7,355.00
7.	St. George's Cres.	19,040.00	18.	Saskatchewan Drive West	16,687.78
8.	Groat Ravine	8,399.23	19.	Grand View	20,352.65
9.	Cameron Avenue	3,192.85			
10.	Highlands	6,907.13			
11.	Whitemud	23,794.00			

[2] The three areas are St. George's Crescent, Cameron Avenue and Strathearn.

records would provide the most reliable data, therefore comparisons of each area would have the same basis. As can be seen in Table III, the three areas of no response will not affect the sample because there is a distribution of the total sample areas. The tax assessment does not directly reflect actual market prices but they are uniform throughout the City. Appendix B explains the methods by which building and land appraisals and assessments are determined. One method of comparison of the different areas that was considered, but later rejected, was the actual or purchase price of the home. The reasons for rejecting this approach are that (1) respondents may not be sure of the market value of their homes at present, (2) if the purchase price was used this would be inconsistent since some homes in the study area were purchased in 1913 while others were purchased in 1970, and (3) there may be a reluctance on the part of owner-residents to reveal such matters to a stranger (the interviewer). One added reason for rejection of the actual or purchase price comparison was that the assessment records were easily accessible for all the residents in these areas, including those who did not answer the interview request letters.

The socio-economic factors determined for the sample were sex, age, occupation, and highest educational level (See Tables V, VI, VII, VIII respectively). Several

crosstabulations were computed to compare sex and age (Table IX) and sex and educational level (Table X). It should be here emphasized that these tables reflect the sample in the population that was interviewed, these results cannot be said to illustrate the characteristics of the total population. It is indicated by the sample taken that these owner-residents can be considered to be at least middle aged, of whom almost 90 per cent have at least a high school education.

TABLE V SEX

Sex	Frequency	Percentage
Male	33	55.0
Female	27	45.0
Total	60	100.0

TABLE VI AGE

Age Groupings (in years)	Frequency	Percentage
0 to 30	1	1.7
31 to 45	19	31.7
46 to 60	24	40.0
61+	16	26.7
Total	60	100.0

TABLE VII OCCUPATION

Source of Occupational Titles: DBS Census Data, 1971

Occupation	Frequency	Percentage
Managerial	4	6.7
Professional and Technical	18	30.0
Clerical	3	5.0
Service and Recreation	3	5.0
Craftsmen, production, process and related	3	5.0
Housewife	19	31.7
Retired	10	16.7
Total	60	100.0

TABLE VIII HIGHEST EDUCATIONAL LEVEL

Highest Level	Frequency	Percentage
High School	12	20.0
Less than High School	7	11.7
Trade & Technical School	4	6.7
University (and Higher)	35	58.3
Other (in this case Nursing)	2	3.3
Total	60	100.0

TABLE IX SEX AND AGE

	Age (in years)			
Sex	30 and Under	31 to 45	46 to 60	61+
Male (Frequency)	0	8	12	13
(Percentage)	0	42.1	50.0	81.3
Female (Frequency)	1	11	12	3
(Percentage)	100.0	57.9	50.0	18.8

TABLE X SEX AND HIGHEST EDUCATION LEVEL

Sex	High School	Less than H.S.	Trade & Tech. School	Univ. +	Other
Male					
(Frequency)	3	4	3	23	0
(Percentage)	25.0	57.1	75.0	65.7	0
Female					
(Frequency)	9	3	1	12	2
(Percentage)	75.0	42.9	25.0	34.3	100.0

The owner-residents were asked to indicate in which type of area they preferred to live: (1) In Edmonton, along the River or ravines; (2) In Edmonton, but away from the River System; (3) Out of Edmonton, but remain in Alberta; or (4) Out of Alberta. It is significant to note that 76.7 per cent preferred the first type location, that is to stay in a similar situation to the one they were in at the present time. Only 1.7 per cent each preferred the second and third choices, while 20 per cent wished to move out of the Province. The deciding factor in the latter cases was the prolonged and severe winter conditions to which Edmonton is prone. Many of those wishing to move indicated Victoria, British Columbia, as their preferred locale, though two persons indicated Hawaii and one Los Angeles.

The respondents indicated what physical, locational, and mental advantages and disadvantages, if any, their pre-

sent sites had compared with other areas in the City of Edmonton. The advantages were arranged in the order they were given (Table XI); the first, second, and third choices were recorded to indicate the most popular reasons for preference of the site.

TABLE XI ADVANTAGES OF THE PRESENT SITE
(Frequency)

Advantage	First Choice	Second Choice	Third Choice
No Response	0	2	18
View	19	15	7
Quiet	12	12	6
Convenient to work, services or schools	10	10	9
Privacy	9	12	8
Nature, Wildlife and Beauty	5	6	6
Non-Prestigious Area	2	1	2
Good Investment	2	0	1
No Traffic	1	2	3
TOTAL	60	60	60

The disadvantages were likewise taken but because of the numerically small number only the first choice was recorded. (Table XII). It is interesting to note that no individual suggested that erosion was a disadvantage to their particular site.

The respondents were also asked if they were planning to remain on their present sites for many more years. The

TABLE XII DISADVANTAGES OF THE PRESENT SITE (Frequency)

Disadvantages	Frequency
None (as a response)	40
Traffic Noise and Pollution	8
Isolation from work, shopping or schools	7
Wildlife and Insects	2
Neighborhood too exclusive	3
TOTAL	60

term "many more years" was used to imply that no other plans had been made that would indicate that movement out of the present site was imminent. Only 10 per cent were planning on moving within the next few years, of which two persons were already in the process of selling their property. It can be seen that while 23.3 per cent wished to leave their present site only 10 per cent were actually moving.

III. PERCEPTION OF THE EROSIONAL HAZARD

The major hypothesis, as stated in Chapter 1, is:

> *In Edmonton, people perceive the erosional hazard when they establish their domicile along the top of the North Saskatchewan River Valley.*

To test the hypothesis, two crosstabulations were designed. The first was used to determine whether or not there was perception of the erosional hazard when residency was es-

tablished and the second was used to determine if individuals perceive that there is an erosional hazard at present. Table XIII gives the results of these crosstabulations.

TABLE XIII INITIAL PERCEPTION AND PRESENT PERCEPTION OF THE EROSIONAL HAZARD

	Initial Perception	Present Perception
Yes	23	34
No	37	26
Total	60	60

In the first test it was found (source of data, question 7) that 23 respondents (38.3%) perceived the erosional hazard at the time they established their domicile while 37 (61.7%) did not perceive it. This data indicates that the major hypothesis is not a valid assumption. Instead it must be said that in the main homeowners do not perceive the hazard when they establish their domicile on the top of the river valley.

This result leads to a subordinate hypothetical statement: People at present perceive the hazard. In the crosstabulation test (source of data, question 8) it was found that 34 residents (56.7%) perceive the hazard as a problem at present while 26 (43.3%) do not. It is there-

fore correct to say that this statement is valid. It was thought that several factors may cause the higher perception at present. Among these factors, to be discussed later, are education level, investment, and age-pessimism relations.

From the data an attempt can be made to discuss the behavioral pattern of the population concerning the erosional hazard. It seems probable that 60 to 70 per cent of the population did not perceive the hazard when they first established their residency at the top of the bank. Through observation of exogenetic processes, either natural or induced, some of the owner-residents in this group become aware of the hazard. Thereby, in the present, between 50 and 60 per cent of the total population is aware of the erosional hazard. The remaining segment of the population did not perceive the hazard when they settled in this area nor do they know of the hazard existing at present.

IV. EDUCATIONAL LEVEL AND PERCEPTION

It was hypothesized (see Chapter 1) that people with higher levels of education would have higher incidence of perception of the erosional hazard at the time they establish their domicile and at present. The expected frequency assumes that people who are well educated are more aware of the hazard owing to advanced educational

experience than are less well-educated persons. It is also thought that with time well educated people perceive their surrounding and interrelationships that develop in it than do the less-well educated. The chi square tests are used to determine the significance of the data, values are acceptable up to the 0.05 level. All computations for chi square problems are given in Appendix E. Two null hypotheses were formulated in order to separately test initial and present perception.

The first null hypothesis states that there is no relationship existing between educational level and initial perception. The data used (source of data, questions 4 and 7) for computing significance are presented in Table XIV.

TABLE XIV EXPECTED AND OBSERVED FREQUENCIES OF EDUCATION LEVEL AND INITIAL PERCEPTION

	Perception				
Education Level	Yes		No		Total
	Ex.	Ob.	Ex.	Ob.	
High School or Less	7.3	6	11.7	13	19
Above High School	15.7	17	25.3	24	41
		23		37	60

The observed frequency for those with an educational level of high school or less 6 (31.6%) perceived the hazard while 13 (68.4%) did not. For those with an education level above

high school (Technical, Trade, Nursing, and University) it was found that 17 (41.5%) perceived the hazard and 24 (58.5%) did not. From Table XIV the chi square value is 0.549 with one degree of freedom. It must be assumed that the hypothesis is not valid as the level of significance is between 0.30 and 0.50, and that there is a probability that this data was obtained by chance.

The second null hypothesis is that there is no existing relationship between education level and present perception. The data required for computing chi square are given in Table XV (source of data, questions 4 and 8).

TABLE XV EXPECTED AND OBSERVED FREQUENCIES OF EDUCATION LEVEL AND PRESENT PERCEPTION

	Perception				
Education Level	Yes		No		Total
	Ex.	Ob.	Ex.	Ob.	
High School or Less	10.8	7	8.2	12	19
Above High School	23.2	27	17.8	14	41
Total		34		26	60

The observed frequency for high school or less is 7 (36.8%) residents who perceive it and 12 (63.2%) who do not. In the above high school group 27 (65.9%) are aware of the erosional hazard at present and 14 (34.1%) are not. From Table XV chi

square is determined to be 4.533 with one degree of freedom. This is significant to the 0.05 level. It can be said, therefore, that educational experience has a direct proportional relationship to present perception. It is thought that this is due to the attitude experienced in higher education whereby phenomena are questioned. When an energistic impingement (see section on the background in Chapter 1), such as the observation of cracks in the ground, is imprinted in the cognitive processes there is a question asked. Perhaps this question is Why?, or When?, or How? The well educated person investigates this impingement through formal or informal inquiry and is thus better informed than less-well educated individuals.

V. ASSESSMENT VALUE AND PRESENT PERCEPTION

The second secondary hypothesis, as given in Chapter 1, states:

> *Those homeowners who live in areas that have higher assessment rates are more aware of the erosional hazard.*

Assessment rates, as shown in Appendix B, reflect the market value and hence the financial investment of the owner. From Table III (Ranking by Assessment Value) an arbitrary division was decided upon to test the hypothesis. The dividing line used was $15,000. The expected frequency assumes that the higher the assessment value (hence investment) the more

aware the person is of the erosional hazard at present.

The null hypothesis states that there is no relationship between assessment values and present perception. The data for chi square are drawn from Table XVI (source of data, question 8 and Table III). The

TABLE XVI EXPECTED AND OBSERVED FREQUENCIES OF ASSESSMENT VALUES AND PRESENT PERCEPTION

	Assessed Value				
	Less than $15,000		More than $15,000		Total
	Ex.	Ob.	Ex.	Ob.	
Perceive	18.7	17	15.3	17	34
Not Perceive	14.3	16	11.7	10	26
Total		33		27	60

observed frequency of those homeowners who have a homesite assessed at less than $15,000 is 17 (51.5%) who perceive the hazard and 16 (48.5%) who do not. For the upper group (those having assessed values in excess of $15,000) there are 17 (62.9%) who perceive the erosional hazard while 10 (37.1%) do not. The chi square value derived from Table XVI is 0.793 with one degree of freedom. The lack of significance of this data indicates that the hypothesis must be rejected as the relationship shown by the raw data may have been derived by chance.

It is, of course, impossible to state that with more

data (possibly the full population of 197) there would be a direct relationship between financial investment and perception. But it seems reasonable to assume that the more money that one is investing in a project the more care would be taken to determine what factors (such as erosion) may possibly have an effect on it. Even though this relationship is not valid in the present sample it is encouraging to note that more than half of each group is aware of the hazard.

VI. AGE-PESSIMISM

The third secondary hypothesis stated that the older a person is the more pessimistic he is about future occurrences of the hazard. Roder,[3] in dealing with flooding at Topeka, Kansas, found "...that the older people viewed the possibility of future floods with greater pessimism than younger people. This correlation may be the result of a generally more pessimistic attitude on the part of older people."[4] This weak correlation of Roder's is not evident in this particular study, rather, it seems, the reverse is true (source of data, question 9).

The null hypothesis states that there is no rela-

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[3]Roder, *op. cit.*, footnote 1.

[4]Ibid., p. 73.

tionship existing between age groups and pessimism about the future occurrence of the hazard. The chi square value was derived from the data presented in Table XVII.

TABLE XVII EXPECTED AND OBSERVED FREQUENCIES OF PESSIMISM AND AGE GROUPS

Future Occurrence	Younger Than 46		Older Than 46		Total
(Pessimism)	Ex.	Ob.	Ex.	Ob.	
Soon	4.3	6	8.7	7	13
Not in Life-time (or Never)	15.7	14	31.3	33	47
Total		20		40	60

The observed frequency shows that 6 (30%) of those younger than 46 (an arbitrary cutoff point in Table VI) feel that the hazard will occur soon while 14 (70%) feel it will not occur during their lifetime. Seven (17.5%) older persons (46 and older) indicated that the hazard will occur again soon and 33 (82.5%) did not think it will occur in their lifetime. The chi square value taken from Table XVII is 1.281 with one degree of freedom. This is significant to the 0.30 level which thereby forces the rejection of the hypothesis. From the raw data one could tentatively produce a "weak correlation" in reverse of Roder's. But the significance level indicates that the factor of chance is too dominant in this problem to be able to make a valid statistical statement.

One criticism of this test could be the interpretation of the term "not in your lifetime." It would stand to reason that one who is in the younger bracket is going to have a longer life span, from the present moment in time, than a member of the older group. During the interview pretest it was found that the term "many years" could not be comprehended or interpreted to mean the same or approximately the same amount of time, "never" was too final of a word for many respondents. Therefore the phrase "not in your lifetime" was adopted as the best term that could be used to describe a long period of time.

VII. AWARENESS OF EROSION IN EDMONTON AND THE INDICATIONS OF EROSION

As has already been mentioned major problems of natural erosion have occurred in Edmonton within the past century (See Chapters 1 and 2). The owner-resident was asked if he was aware of any other areas of Edmonton that have suffered from erosional problems; 47 answered in the affirmative, 12 said they did not know of any specific areas, while one person noted that Edmonton has never had any erosional problems at any time since the beginning of human occupation. Respondents gave many examples of areas, by name, that had suffered damages from erosion, only the first and second choices were used and absolute frequencies of each were recorded (Table XVIII). It is

postulated that the reason for the Summit Point area being the most recognized is due to the large green plastic sheeting that was erected on the bank of the river by the property owner to prevent surface water from eroding his land (Plate 1). This structure is very conspicuous and is associated in many peoples minds with natural erosion. Grierson Hill has ceased being an engineering problem to the City since 1963, its lack of publicity in the past eight years is probably a factor in its second placement in areas of erosion, despite its large magnitude.

TABLE XVIII OTHER AREAS OF EDMONTON THAT HAVE SUFFERED FROM EROSIONAL PROBLEMS: 1ST AND 2ND CHOICES

Area (See Figure 2)	Choice (Frequency)	
	1st	2nd
Summit Point	20	9
Grierson Hill	10	4
Valley View	5	2
Highlands	5	1
Groat Ravine	4	1
Taylor Hill	1	0
Mill Creek Ravine	1	0
Outside Edmonton (to include the rest of the world)	1	1
St. George's Crescent	0	1
Provincial Legislature Bldg.-High Level Bridge	0	1
Westbrook (Whitemud Creek)	0	2
Gold Bar	0	1

Plate 1

Summit Point. Note the technical adjustments along the top of the bank, the retaining walls and the plastic sheeting (to prevent runoff erosion). A small landslide is to the left of the plastic sheeting.

Plate 2

Valley View. Subsidence resulting from fill being pushed over the valley slope during construction and overloading it. There is slow continuous movement (15 feet in 10 years) though most of it occurred in the first two years. A small useless retaining wall is at the top.

Plate 3

Valley View, adjacent (south) to Plate 2. Note the tilted shrubs and the displaced fence. The aspen trees in the background indicate the natural slope.

Plate 4

Groat Ravine. This mudflow occurred in 1966, the toe of the flow has been left by the City Engineers to prevent any further movement.

Plate 5

Whitemud Road and 45th Avenue. This recent mudflow (Summer 1970) is in bedrock, the dark zone to the right of point A is a spring line in a coal seam. Low willows and junipers have recolonized the flow.

Plate 6

Riverside Crescent. The topography of this area shows pre-settlement slumps. Note the closeness of the homes to the top of the slope.

Plate 7

Highlands (Ada Blvd. and 109th Avenue). Surface cracking above a landslide which occurred in April of 1971.

Plate 8

Highlands (West of Plate 7). The circular headwall of the landslide-mudflow which occurred in April 1971. A preglacial thalweg runs under this area (See Figure 2).

Plate 9

Highlands (same as Plate 8). The headwall and source area of the landslide-mudflow, note part of a snow fence next to the figure. At point A there is surface runoff draining into the slide area (at the time the photograph was taken it was raining).

The final section on awareness of the erosional hazard deals with the owner-residents' knowledge of the physical problem itself. Before remedial adjustments can be made it is essential for the owner-resident to become familiar with the first indications of erosion. When asked if they were aware of any physical indications, on their property, that would cause them to believe some type of erosion was about to take place, 35 felt that there are indicators and 25 said there are none. Those that replied negatively felt that at one moment the ground was there but that at a particular point in time, when a stage of relative catastrophic inequilibrium was reached the ground collapsed. There were four basic indicators chosen by the respondents who answered in the affirmative. The cracking of the soil, in either straight lines or as concentric circles was denoted by 57.1 per cent as an indication of an erosional problem. A further 25.7 per cent felt that subsidence of their property was the prime indicator of imminent erosion, 11.5 per cent noted that vegetation indicated that movement of the river bank had taken place in the past and would probably take place again. An additional 5.7 per cent felt that water was the best indicator for erosion, either as continuous wet weather or as an accumula-

tion of surface water. It has been seen, in Chapter 2, that continuous rain and the accumulation of water at or near the surface can produce large mass movements in the valley slopes in Edmonton. It would be incorrect to establish one of these four indicators as the "correct" response. It is very possible that two or three or all may be evident on one particular slope during a certain point in time and space.

VIII. CONCLUSIONS

The major hypothesis was shown to be not valid. Instead it can be assumed that in Edmonton most people do not perceive the erosional hazard when they establish their domicile at the top of the North Saskatchewan River Valley. A subsequent hypothetical statement emerged from the major hypothesis and proved to be a valid assumption. It stated that at present most people perceive the hazard.

In order to investigate the relationships established by the invalidation of the major hypothesis it was hypothesized that higher education level and perception as well as financial investment and perception were directly related. Through statistical tests it was found that the only relationship which could be proven valid was that which exists between present perception and well educated

residents. It was thought that age-pessimism might also be a factor in perception but no valid assumptions could be drawn from the data though the data did appear to contradict correlations observed in flood hazard studies.

The prime interest in behavioral geography is not the characteristics, preferences, or perceptions (important though they may be) but are instead, the adjustments. In the following chapter the individual's choices of adjustments are explored, to include those actions that he himself can take and those that he feels others, to include the three levels of government, should take.

CHAPTER 4

ADJUSTMENT TO THE EROSIONAL HAZARD

I. INTRODUCTION

Man, by nature, utilizes the most favorable places in his environment, those areas that provide him with amenities, that are accessible, and give him an economic advantage. His management of the homesite resource is affected by many variables: his perception, education, occupation, age, the physical geography, and the attitudes and adjustments that he takes. In the particular situation dealt with in this study when natural erosion is an active geomorphic process, the individual must make a decision on this hazard if he perceives it, which could have an effect on his financial investment. In fact, the decisions or adjustments taken are a clear indication of the individual's perception.

There are two types of adjustments, as outlined in Chapter 1: (a) the technical adjustment is one which affects the cause of the problem or possibly modifies the hazard itself, and (b) the social adjustment is either psychological and concerns the individual or is socio-

economic and is in reference to a group of persons or an institution. Burton, Kates, and White noted that the "...dichotomy between technological and social adjustments is useful, but can also be misleading."[1]

> *The dichotomy is further complicated because it coincides, to a large degree, with different allocations of cost. Technological solutions are commonly carried out largely at public expense. Social adjustments are often left to private citizens, or their cost is borne largely by a few people. There is often strong pressure, therefore, for technological solutions because they involve a shift of the costs away from vociferously objecting individuals to the society at large.*[2]

In the context of Alberta this division of cost of technological and social adjustments does not seem to apply, rather, it seems, that the individual must bear the financial burden for both types of adjustments.

It must be recognized that no individual has the complete theoretical range of choice open to him. He may reject some of them as they may seem unwise to him, other adjustments may not occur to him because of either his practical or formal education or both. "He simply may feel that he must without question go on doing in one year what he did in the preceeding year and what his father did before

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[1] I. Burton, R. W. Kates, and G. F. White. The Human Ecology of Extreme Geophysical Events, Univ. of Toronto, Natural Hazard Research Working Paper No. 1, 1968, p. 13.

[2] Ibid., pp. 13-14.

him."[3] This lack of action may be the result of a form of conservatism, for the individual may also think that his method of control is providing the best results possible, and that there is, therefore, no reason for him to change as he is sure another method would not be more effective.

In this study both the technical and social adjustments were investigated, with emphasis being placed on the latter. The only two social adjustments studied were insurance and government assistance, as these were the institutions to which 35 per cent of the sample population would turn if financial loss occurred due to natural erosion.

II. TECHNICAL ADJUSTMENTS

A technical decision of adjustment is one which has a direct effect upon the hazard itself. It is considered to be a corrective or preventive measure. The last secondary hypothesis (see Chapter 1, Section III), states:

> People do not believe there are technical preventive measures which can be taken to stop or reduce erosion.

The raw data refutes this hypothesis and shows that 50 respondents (83.3%) indicate that the erosional hazard

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[3] G. F. White, "The Choice of Use in Resource Management," Natural Resources Journal, Vol. 1, 1961, p. 28.

Plate 10

Valley View (South of Plates 2 and 3). A man-induced landslide, the former slope was steep and the owner used fill to construct a lawn. The owner claims a city water main broke near his home and the water saturated the area thus causing the slide. He is taking legal action against the City. Note the closeness of the house to the slide. It first occurred in the Spring of 1971.

Plate 11

Quesnell Ravine (Whitemud Freeway). A man-induced landslide caused by road construction. It occurred in the Spring of 1971, note the broken medal fence.

can be stopped or reduced by preventive or corrective measures, 8 (13.4%) stated that prevention or control is impossible, while 2 (3.3%) gave no answer.

The classes of prevention can be divided into two types: (1) pre-construction measures and (2) post-construction measures (Table XIX).

TABLE XIX PREVENTIVE CLASSES

Class Type	Measure	Frequency of Choice
Pre-Construction	No Construction near valley edge	8
	Seek Professional advice before building	4
Post-Construction	Retaining Walls and Pilings	10
	Vegetation Cover	24
	Proper Drainage	4
		50
	No Response	10
	Sample Total	60

The pre-construction measures are not true technical adjustments. These become evident post facto, that is to say, they should have been recognized prior to the owner-residents establishing their domicile at the present site. The two pre-construction measures mentioned are not themselves physical actions but are, rather, approaches that should be taken to avoid causing erosion to become a hazard.

The restrictions of construction on the edge of the river valley was chosen by eight individuals. Many owner-residents (including those that did not indicate this response) assumed that construction on the river bank produces overloading which physically weakens the load capacity and, hence, the stability of the valley slopes. In the General Plan for the City of Edmonton the required setback (that is, the distance away from an object, be it street or property line) from the top of the bank is 25 feet.[4] Many homeowners were aware of this requirement as it was one of the stipulations that had to be met for construction of homes along the river valley under Zoning Bylaw 2135.[5] It was also suggested by these no-construction respondents that fill should not be placed at the top of the river valley and homes constructed on top of it. There are many problems that have resulted from the use of fill, such as improper compaction and the use of incompetent materials, which can cause uneven settling and possible mudflows. The second pre-construction measure, chosen by four individuals, is to seek professional advice prior to construction of the home. Before building either the property owner (for whom the house is built) or contractor should enlist the aid of an engineering consultant firm and have an engineer conduct soil

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[4] The Edmonton Journal, May 19, 1971, p. 2.

[5] The City of Edmonton, Zoning Bylaw 2135, Revised Copy, Nov. 1970, 162 pp.

mechanic and geologic tests. This will determine the safe load factor for the foundations of the buildings. It is important to note that some insurance companies require these engineering tests for homes where a risk may be present prior to extending coverage. Most engineering consultant firms are not requested to do surveys until after an erosional problem becomes evident. Possibly one deterrent of soil surveys is the price, an extensive survey would generally cost from $2,500 to $3,000.[6]

The post-construction measures are those actions which can be taken at the present, after the domicile has been established. The building of retaining walls and the placing of pilings into the bank was suggested by 10 respondents as a possible prevention for natural erosion. It was reasoned by those individuals who suggested this measure that retaining walls and pilings would allow the homeowner to use fill which subsequently would permit him to build closer to the river valley. Though retaining walls were recommended by these individuals it was recognized that there must be allowance made, during construction, for drainage, in order to prevent the building up of hydrostatic pressure.

The preventive measure with the highest frequency of choice (24) was vegetation cover. Respondents expressed the

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[6] B. J. Devose, Consulting Engineer, R. M. Hardy and Associates, Edmonton, Pers. comm., October 7, 1971.

necessity of keeping the natural vegetation cover on the river or ravine banks whenever possible. It was suggested that the roots of the trees and shrubs provided an effective anchor for the soil. Where the natural vegetation had been disturbed, either by natural erosion or through human destruction, it becomes necessary to plant fast growing and deep-rooted shrubs such as caragana (Caragana aborescens Lambert), choke cherry (Prunus virginiana Lambert), and willows (Salix spp).[7]

The last preventive measure is the proper drainage of water, this measure was chosen by four respondents. If water is allowed to pond at the surface and hence seep into the soil there is a danger that erosion in the form of mudflows may occur. Several residents in the Summit Point area have left hoses running on their river valley gardens for long periods of time thus saturating the soil, both natural and fill, the saturated material lost its molecular cohesion and flowed down into the valley. Plate 10 illustrates the landslide that can result from excessive water.

Where water flows downhill naturally, from springs, snowmelt, or rainfall, it is necessary to provide proper channels which will permit drainage over the valley slopes

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[7]From E. H. Moss, Flora of Alberta (Univ. of Toronto Press, 1967), 546 pp.

into the river. Proper channels are interpreted to mean either in pipes or channels that are lined which prevents the water from draining into the subsoil and, hence, causing erosion.

It should be emphasized here that a majority of the sample (50) feel that technical adjustments will provide effective controls against natural erosion. From the interview there is no indication as to how widespread these adjustments are, except to say that the respondents that chose the post-construction measures noted that either they themselves had used these measures or were positively certain of friends or neighbours in Edmonton that are or were using them.

III. SOCIAL ADJUSTMENTS

In hazard studies the question arises as to where the owner can go if he suffers loss to his property and/or home. Within the law there is no recourse for the homeowner who suffers damages in Alberta nor do insurance companies provide protection on a regular basis. It is significant to note that 61.7 per cent of the sample realized that there was nobody to whom they could turn, while 3.3 per cent did not know what they could do. Of special interest is the comparison of these figures with work done in

Eastern Canada. Parkes[8] also found that more than 60 per cent of the homeowners in the Ottawa area considered themselves responsible for damages caused by landslide. There were two social adjustments to which owner-residents thought they could turn, both are of the socio-economic type: (a) homeowners insurance (18.3%) and (b) government aid (16.7%).

A. Insurance

In order to determine whether insurance coverage was available for homeowners who live in areas that are subject to natural erosion, inquiries were sent to nine City insurance firms (Appendix D). The companies were not statistically chosen as there were no methods that were available whereby a total population could be determined. Therefore, the nine chosen were picked after consulting the yellow pages of the Edmonton Telephone Directory. The responding firms were given assurance that their answers would be kept confidential. Each company was asked four identical questions:

1. Do you designate certain areas of the City as possible insurance risks? If so, which areas?

2. When you write a policy for a single family

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[8] J. G. M. Parkes, Awareness of and Adjustment to a Natural Hazard: Sensitive Clays in the Ottawa-Hull Region, Dept. of Geogr., Univ. of Western Ontario, Unpublished M.A. Thesis, April, 1971, p. 61.

dwelling, along the river valley or a ravine, do you normally include landslide or subsidence insurance coverage?

3. Do you sell special landslide or subsidence insurance? If so, is the cost much higher than an ordinary homeowners policy?

4. What is your definition of the phrase "Act of God" (vis major) in regard to homeowners insurance?

Vis major is the judicial term for Act of God.

In response to the first question it was found that no companies declare specific zones of the City as risk areas, but they do investigate each separate site and judge them on their particular merits.

> *If there was a certainty of something occurring that is not a risk, it should not be covered by an insurance policy. The question then raises itself that there can be a difference of opinion and the only satisfactory solution is to have an Engineering Report from a reputable firm.*[9]

The demand for coverage of the natural erosion risk is quite small. Normally homeowner policies exclude landslide, subsidence, and erosion unless they are a direct result of fire or explosion. Of the six firms that replied none would offer landslide or subsidence insurance. The only possible way to collect on these two would be to take out earthquake insurance and then establish proof that an

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[9] Quote from insurance firm, confidential.

earthquake was the triggering force; only one firm of the six offered earthquake coverage which is a rather safe stand to take as Edmonton has not suffered damages from earthquakes in historic times.

Many insurance firms feel they would be at a disadvantage if insurance were offered to those individuals who lived along the river valley. Insuring those homeowners would be an unsound policy for a firm to take. As one company stated it:

> *Consequently, we are unable to collect enough premium from the few people living close to the river to justify providing the protection for them. The only way around this would be to provide the coverage for everyone, and make everyone pay a premium for it, but in effect only provide the coverage for those people who live close to the valley.*

There is such a limited market for this coverage that insurance companies are not "...interested in getting involved in it."

The term "Act of God" is rarely used in underwriting insurance policies, it is, however, commonly used as a defense in legal liability actions. English common law, on which Canadian Judicial Law is based, uses the following definition for "Act of God," as given by Lord Chief Justice L. J. James in 1876:

> *Any accident due to natural causes directly and exclusively without human intervention, such as could not have been prevented by any amount of foresight and pains and care reason-*

able to have been expected.[10]

It can therefore be seen that insurance coverage of the 18.3 per cent (11) respondents is not likely. It is significant to note that only one individual had bought subsidence insurance as such. This indicates that there must be an insurance company in Edmonton that offers this coverage but that this firm is reluctant to inform other insurers of this service for none of the six that replied were aware of such policies in Edmonton or for that matter if there was a company offering this coverage in Alberta. None of the remaining respondents (10) knew absolutely that they had insurance coverage. This would seem to indicate an ignorance on the part of these individuals as to what is actually covered by their homeowners insurance policies.

Parkes, in Ottawa, found that only one firm would provide landslide coverage, but because of a careful definition of the word "landslide" the company was considered to have a safe investment. The only possible way to collect was to prove that a landslide had originated above the home. However, if the house sat on top of the bank and the slide occurred below the house this was interpreted, by the company, as subsidence and, hence, was not within the

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[10] S. R. Hobday, Coulson and Forbes on the Law of Waters, Sea, Tidal, and Inland, and Land Drainage, 6th Edition Editor (1st Edition, 1880), Whitefriars Press, London, 1952, p. 174.

insurance coverage. Other companies in Ontario have ceased offering landslide coverage since 1959 when many of them lost considerable amounts of money in landsliding in the Toronto suburb of Scarborough Bluffs.[11]

It can be concluded that insurance is not a social adjustment that is readily available to homeowners in Edmonton. The one person, in the sample, who has a policy which covers subsidence of his house and swimming pool must be considered an anomaly. Because of the lack of knowledge by other insurance firms of any such coverage in Edmonton, and to the lack of this type of coverage in Ontario, one must eliminate insurance as an acceptable adjustment in Edmonton.

B. Government Aids

Although only 16.7 per cent (10) of the sample felt that one of the three levels of government (Federal, Provinsical, or City) would be a positive alternate adjustment the total sample's knowledge of existing preventive measures was investigated. Respondents were asked if they were aware of existing programs, either legal or through physical actions, that any or each of the three levels of government possessed. Responses were recorded whether or not they were true. Only the City possesses preventive programs (for its

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[11] Parkes, op. cit., footnote 8, p. 123.

own property), this fact is reflected in Table XX. It is interesting to note that two thirds of the sample do not know if there are or are not Federal or Provincial programs.

TABLE XX DO GOVERNMENT PROGRAMS EXIST?

Government	Awareness (%) Yes	No	Don't Know
City	58.3	15.0	27.7
Provincial	3.3	30.0	66.7
Federal	8.3	23.3	68.4

The most common City preventive program that was mentioned was the setback that is required by Zoning Bylaw No. 2135. Though the bylaw stipulates a 25 foot setback many residents felt that this should be increased to 50 feet, consequently they wanted their own lots deepened 25 feet as compensation. Many also wanted the City to buy the land adjacent to the river valley as this would allow greater access to the general public. This last statement could also have a financial interpretation, as the assessment on the lot would be lowered as the amenities factor would be reduced in the computations for tax rates. The second most chosen program was the City's policy on vegetation along the river valley. It has been the policy of the City to require the architect or owner to write and sign a letter

saying he (or they) will not cut down any trees, tear out shrubs or grasses, or throw any construction debris or fill over the side of the valley.[12] The Parks and Recreation Department, through legislation, also plants valley slopes that are the property of the City, especially those adjacent to roadways.[13] Several individuals said that the City has a policy of terracing the valley sides. This is true for some areas where the banks have been disturbed by road construction. It has been practiced in very limited circumstances as it is not a sound engineering practice. This is because water is not allowed to drain along the surface and subsequently enters the sub-strata and, hence, causes the slopes to be weakened. Several persons felt that the City should construct retaining walls along the North Saskatchewan River's edge. Legally this cannot be done as the erection of retaining walls would be contrary to common law.[14] The City Engineering Department has attempted to place retaining walls on one section of the river, below St. George's Crescent, but owing to the common law precedent it has been

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[12] Policy sheet from the Parks and Recreation Departmant, City of Edmonton, which is given to each owner applying for a building permit, no date, 1 page.

[13] The Municipal Government Act, Revised Statutes of Alberta 1970, vol. 4, Section 192, p. 3782.

[14] English Common Law, precedent of Menzies vs Earl of Breadalbane by Lord Bligh, Series 414, 1828, as given in J. V. V. Fitzgerald, The Law Affecting the Pollution of Rivers and Water Generally, Knight and Co., London, 1902, p. 6.

Plate 12

St. George's Crescent. The terracing of the slope above the construction of a freeway, note the rip-rap at the river's edge.

restrained by Provincial Courts. The Engineering Department has, in the past, suggested that the river be entirely controlled with the use of retaining walls throughout the City's limits.[15] The City does, however, place retaining walls above roadways within the river valley, such as below the Legislature Buildings and above Walterdale Road. It does this only to protect its own property and does not recommend that retaining walls be constructed for or by homeowners.[16]

When dealing with the Provincial Government's role very few respondents felt there were any preventive programs that are or could be initiated. Those that replied that there were preventive programs felt that the Province would do this through legislation. In reality the Province of Alberta has delegated all its responsibility to the City[17] and has no actual obligation that applies to homeowners with concern to natural erosion.

The Federal Government prior to 1930 owned the North Saskatchewan River as provided for under the British

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[15] R. J. Matthews, Chief Roadways Engineer, City of Edmonton, Pers. comm., August 10, 1971.

[16] Ibid.

[17] The Municipal Government Act, op. cit., footnote 13, Sec. 169 (3), p. 3771.

North America Act of 1867.[18] At that time the Government of Canada provided the Province of Alberta with the same rights that were afforded the four original provinces under the BNA Act, section 109, at the time of Confederation, which was that all public lands would be transferred to the Province in the name of the Crown (excluding Indian Reserves, Defense installations, and National Parks).[19] The Federal Government is "...rendered virtually impotent by constitutional constraints."[20] Through the National Research Council, the Geological Survey of Canada, and the Department of Energy, Mines, and Resources (and with lesser degrees of activities, the other Federal Departments) the Federal Government acts as an advisory body which issues research information on potential hazards. Therefore it can be seen that there is a dilemma created, the information is provided (or can be) but the enforcement powers are non-existent.

The 8.3 per cent of the respondents who answered that the Federal Government has programs against erosion believed this was provided for in the Navigation Act which gave ownership of the river bed to the Government of Canada.

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[18]The British North America Act, Statutes of Canada, 30 and 31 Victoria, 1867, Chapter 3, pp. 3-41.

[19]The Alberta Natural Resources Act, Statutes of Canada, 20 and 21 George V, Chapter 3, May 1930, pp. 13-23.

[20]Parkes, op. cit., footnote 78, p. 103.

However the Navigation Act has been repealed and the ownership of a river bed by the Federal Government only applies in the Northwest Territories and the Yukon Territory.[21] The correct "response" to whether or not the Federal Government has existing programs is no.

It has been shown that over 60 per cent of the respondents knew they could not turn to anyone in case they suffered financial loss caused by natural erosion. The social adjustments of insurance and governmental aid have been investigated and indicate that little assistance from these institutions is available. Those who felt that insurance or government aid was available seem, from the study of insurance firms and government statutes, to be guided by a lack of information.

IV. SHOULD GOVERNMENT HELP BE AVAILABLE?

As has been shown above, the legal responsibilities and liabilities of governments are a controversial subject. What one thinks a government should do and what the statutes say a government can do may be two different things. The responses that are given to a question of responsibility reflect the psychological dimension of internal versus external control; that is, whether one holds oneself respon-

[21] The Territorial Lands Act, Revised Statutes of Canada 1970, vol. VII, R. S.,C. 263, Section 10, p. 7344.

sible to make up the losses caused by natural erosion or whether one places this responsibility on an outside influence or institution. In order to determine this psychological information the owner-residents were asked:

> Do you think government help should be available to people who suffer damages from natural erosion?

If respondents answered in the affirmative they were to indicate what level of government(s) should make such help available and why. If a respondent gave a negative answer he was also asked why. The sample population divided down the middle, with 50 per cent yes and 50 per cent no.

The reasons given for negative responses revolved around the phrase caveat emptor.[22] These individuals felt that it was their personal risk for buying property in their particular location of the City, and, therefore they should bear the responsibility of their choice. This negative response indicates an internal psychological dimension.

Of those individuals who replied affirmatively seven choices of levels of combinations of levels of government were given (Table XXI). It can be seen that the City has been indicated as that level which should bear the burden of legal responsibility for providing assistance to homeowners

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[22] Latin term for "Let the buyer beware," used as a judicial term also.

TABLE XXI LEVELS OF GOVERNMENT RESPONSIBLE FOR ASSISTANCE

Level(s)	Frequency	Percentage
City	19	63.4
Province	3	10.0
Federal	1	3.3
City-Province	4	13.4
Province-Federal	1	3.3
City-Federal	1	3.3
All Three	1	3.3
	30	100.0
No Government Help	30	
	60	

who suffer damage from natural erosion. The City, in some sort of association, has been held responsible by over four fifths of the affirmative respondents. This preference for the city is seen in the reasons given for why government aid should be available (Table XXII). Several respondents

TABLE XXII REASONS WHY GOVERNMENT SHOULD PROVIDE ASSISTANCE

Reasons	Frequency	Percentage
Taxes (Assessment)	12	40.0
Construction Permit	10	33.4
Conservation	1	3.3
Act of God	4	13.4
No Reason Given	3	10.0
	30	100.0
No Government Help	30	
	60	

stated that the two higher levels of government must be present in assisting homeowners because they felt that the senior governments are responsible for the actions of the junior.

It is the feeling of many of the owner-residents that because their taxes are higher than the homeowner who lives away from the river system they should receive more services and protection. Other respondents have indicated that since the City has given them construction permits this signifies that the land is safe to build on, subsequently, if there is any erosion then the City is responsible for making up the loss. The conservation label is vague. It was reasoned that the government concerned, in this particular case the City, would want to keep the river's bank in the same condition and position in which it is at present. By the phrase "Act of God," as given as a reason for government assistance, the individuals concerned felt that natural erosion was beyond the control of man and was therefore not the responsibility of the owner-resident. One possible corrective measure suggested by the "Act of God" respondents was the offering of governmental insurance against natural erosion, similar to that which is offered to farmers and homeowners through Provincial hail insurance. These above reasons are external dimensions in psychology, for they are an attempt to place the responsibility on something or someone outside oneself.

Using two socio-economic factors, sex and age, an investigation was attempted to determine what types of individuals were prone to external or internal responses. Seventeen women gave external responses while only 13 men did, internal responses were given by 10 women and 20 men. This produces an average of about 60 per cent of the women who give external replies and 60 per cent of the men who reply internally. Age does not seem to be a factor. The responses for all age groupings was almost exactly even.

V. THE LAW

Throughout this chapter there have been continual references to what the three levels of government can or cannot do concerning natural and man-induced erosion. In concluding the social adjustments open to individuals facing these problems it is best to return to the law, to determine who is liable for natural erosion if anyone.

A. The Federal Government

In the Alberta Natural Resources Act of 1930[23] the Government of Canada turned over the Crown's rights to the North Saskatchewan River. If land is owned by the Federal Government, a situation that does not occur along the river

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[23] The Alberta Natural Resources Act, *op. cit.*, footnote 19.

in Edmonton, there have been occurrences where it will assist leasees to relocate if they are endangered by natural erosion.[24] Generally it has been found that Federal Government agencies feel "...little responsibility for the safety of those located in high-hazard areas. (They believe)...this responsibility lies with the provincial and municipal levels of government."[25]

B. The Provincial Government

The ownership of the river bed and water is reserved for the Crown. This ownership is based on English common law. Prior to 1930 the Government of Canada held Crown rights but since that year these rights have been exercised by the Province. There have been legal questions raised as to how much of the river is owned by the Province.

> *The area under the jurisdiction of the Crown may be defined by the following two criteria: all the parts of the bed and channel which are covered by the average high water mark: in addition the Crown also owns the shore which is held to consist of that land in proximity to the water's edge that is either unvegetated or which has a distinctive vegetative cover by reason of this proximity.*[26]

According to the Manual for the Survey of Dominion Lands, item

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[24] B. Long, Engineer with Dept. of Public Works, Gov. of Canada, Pers. comm., April 28, 1971.

[25] Parkes, op. cit., footnote 78, p. 100.

[26] Anonymous, Report on City Interests and the Use of Navigable Streams Within Edmonton, City of Edmonton, Unpublished Report, n.d., p. 1. (Planning Dept.)

194, "...the limit of the bank is the line where the vegetation ceases, or where the character of the vegetation and soil changes."[27] In essence this establishes the Province as the sole riparian rights holder in Edmonton, with one exception (where a homeowner lives on land in Summit Point and owns the entire valley slope to the river's edge).

The Province has, however, relinquished the management of the river and its banks to the municipalities along it, through the Municipal Government Act:

> *Subject to every other Act, a council has the control and management of the public highways, roads, streets, lanes, alleys, bridges, rivers, streams, watercourses, lakes, and other bodies of water within the municipality, including the air space above and the ground below.*[28]

The sole situation that would involve the Provincial Government in litigation proceedings would be when the Province, through construction of public works, caused the damage to occur (man-induced erosion). In this particular instance the Province becomes liable for its actions in the same manner as a private individual.

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[27] Ibid.

[28] The Municipal Government Act, op. cit., footnote 13, Sec. 169, p. 3771.

C. The City Government

The City of Edmonton has no set policy of its own.[29] All programs and responsibilities are given by the Provincial Government (as the City is a creation of the Province) through the above mentioned Municipal Government Act. The City is not liable for damages caused by natural erosion. It relies on caveat emptor as a defense in litigation proceedings, as in the case concerning Grierson Hill where a homeowner was attempting to recover financial loss and receive protection from natural erosion:

> *A check with the Assessors Department indicates that...(the complainant)...acquired the property in 1960 and should therefore have been quite aware of conditions when it was purchased.*[30]

Erosion is considered to be a natural process to which the City feels it has no legal obligation. As has been stated above, the City, by authority of the Municipal Government Act, manages the river bank, but as the manager it is only liable for damages incurred during the construction of public works, with compensation being "...beyond any advantage that the claimant may derive from the contemplated work."[31]

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[29] H. F. Wilson, City Solicitor, City of Edmonton, Pers. comm., August 10, 1971.

[30] J. D. A. Macdonald, City Engineer, Memorandum to the City Commissioners, City of Edmonton, August 7, 1964, p. 2.

[31] The Municipal Government Act, op. cit., footnote 12, Sec. 131, p. 3753.

In the past sub-section, dealing with internal versus external responsibility, many of the respondents felt that the City should bear the burden of offering assistance because it assessed property taxes and issued construction permits. Within the City of Edmonton the property owners pay a tax on their property and buildings, this income is used to provide services such as maintenance of roadways and utilities, police and fire protection, and the salaries of City employees. There were only 197 owner-residents, as of January 1, 1971, in the City who live along the river valley and it is true that these properties have a greater assessed and taxable value than other areas in the City. However, these individuals living along the river system are a small minority of the total households in Edmonton, subsequently the total taxes received from those that live away from the river valley far exceeds that paid by those adjacent to it. "Why should those homeowners who have a dwelling on a piece of flat ground which would not normally be affected, pay for those who are much more exposed?"[32]

By law, the City is not responsible for damages after it has issued construction permits.[33]

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[32]Wilson, op. cit., footnote 28.

[33]The Municipal Government Act, op. cit., footnote 12, Sec. 240 (1 & 2), p. 3803.

> *So far as public bodies are concerned, the law is clear that the granting of a building permit...does not impose any liability upon the public body.*[34]

It is the responsibility of the individual owner, architect, or construction firm to establish that a particular site is safe for construction. The City assumes that these individuals will take the necessary precautions prior to construction and only requires site determination as given in Zoning Bylaw No. 2135 or as required by the Parks and Recreation Department.

D. The Individual's Legal Rights

From the above three sections it seems reasonable to infer that the individual is void of rights. He cannot hold any of the three governments responsible for normal erosional loss. Neither can he recover his loss from the City to which he paid property taxes and which issued him a permit to build (though he may have bought it from another person or inherited it). There are, however, legal approaches open to the individual. The most common is through the proof of negligence on the part of the builder. In the Code of Hammurabi (2130-2088 B.C.) the builder suffered the same consequences as the homeowner:

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[34] J. Pollock, "Legal Implications of Landslides," Landslides and Subsidence, Proceedings of the Second Geologic Hazard Conference, H. Fisher (Chairman), Los Angeles, California, May 1965, pp. 75-76.

> *If a builder builds a house for a man and does not make it fair, and the house which he has built collapses and causes the death of the owner of the house, that builder shall be put to death.*[35]

The modern builder has no fear for his own life should a house he constructs collapse, but he still faces the possibility of a large civil lawsuit if negligence can be proved. For if a person establishes himself as one who can offer professional advice he must take responsibility for any advice or actual work that he performs while acting in the capacity of a professional.[36]

The proof of negligence, as required by the court, is that the construction firm did not use ordinary care. "This means they should have a preliminary soil investigation made of the property, including both the soil mechanic aspects and the geologic aspects."[37] If the developer follows the advice of the engineering firm which conducted the soil tests it "...will be held to have exercised ordinary care, and will be held not to have been negligent, even if a slide should occur."[38] However, in the City of

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[35]D. R. Brown, "Hillside Development Controls in Perspective," Landslides and Subsidence, Ibid., p. 51.

[36]Gent et. al. vs Wilson (1956), Dominion Law Report, vol. 2, 1956, p. 165; This is in reference to a medical case but is quoted in other cases dealing with engineering negligence.

[37]Pollock, op. cit., footnote 34, p. 75.

[38]Ibid.

Brantford vs Kemp and Wallace-Carruthers and Associates Ltd. (1960) the Supreme Court of Canada held that the engineering consultant firm (Wallace-Carruthers and Associates Ltd.) is liable as it did not apply the standard of professional care required; since the construction firm (not sued) and the architect (Kemp) were only following the recommendation of the consultant firm they were excused.[39]

In essence, the individual can only rely on his own resources and knowledge. The Governments, through legislation, are supra jure (above the law) in all cases dealing with natural erosion. There is, however, a growing concern, within political circles, that governments may be liable because of failure to act, "...that is, failure to take preventive measures, might leave...(governments)... with legal liability."[40] The governments are, understandably, not enthusiastic about such programs for common law stipulates that once the duty is created the government is bound to it "...not withstanding any accident by inevitable necessity."[41]

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[39] The City of Brantford versus Kemp and Wallace-Carruthers and Associates Ltd. (1960), Dominion Law Review, vol. 23, 1960, pp. 640-655.

[40] H. Fisher, "The Role of State Government," in Landslide and Subsidence, op. cit., footnote 33, p. 7.

[41] English Common Law, precedent of Rylands versus Fletcher, Law Review 3, H. L. 341, 1868, in Hobday, op. cit., footnote 10, p. 173.

VI. DISASTER

Throughout this study there have been reminders that the erosion in Edmonton is not a major hazard. The fact that a major disaster has not occurred in the past does not mean that there is no danger of one happening in the future. A disaster is a sudden release of a large magnitude of energy that cannot be reflected, absorbed, or buffered by the ecological system which leads to dramatic harmful events on the human use system. The question arises, what can the individual do should such an event occur? The answer is simple, there is no recourse for the individual. However, the three levels of government all possess programs for combatting natural disasters.

The City Council of Edmonton has been empowered by the Provincial Government to grant aid to sufferers from fire, flood, tempest, or other disaster. The Council "...may expend money of the municipality for any purpose considered necessary in the circumstances."[42] The Province can, itself, provide aid to areas in conjunction with that which is found in the Municipal Government Act as stated above. In the Spring of 1971 the Provincial Department of Public Works assisted homeowners in the Town of Athabasca, approximately 90 miles north of Edmonton, to move their

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[42] The Municipal Government Act, op. cit., footnote 13, Sec. 153 (2), pp. 3759-3760.

houses back from the Athabasca River as the river was eroding the banks at a dangerously fast pace.[43] The Federal Government, in June 1968, assisted homeowners at Fort Smith, Northwest Territories, when a large landslide destroyed houses along the Slave River. They provided the land, temporary housing, and exceedingly low interest rate loans to homeowners who wished to re-establish themselves at the townsite.[44] The Federal Government in other parts of Canada has also cancelled all mortgages in areas where major disasters have occurred, such as the St. Jean-Vianney, Quebec, quick clay landslide in late Spring 1971.

It can be seen, therefore, that the individual in Edmonton will receive governmental assistance should he survive a catastrophic event. In terms of historical evidence of such events in Edmonton this information is of slight consolation to the owner-resident.

VII. CONCLUSION

The adjustments that are open to individuals are of one of two types, technical or social. It has been found that a majority of the owner-residents believed that natural erosion could be prevented through the use of

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[43] B. Ramsay, Dept. of Public Works, Province of Alberta, Pers. comm., May 31, 1971.

[44] B. Long, *op. cit.*, footnote 24.

technical adjustments, either by pre-construction measures or post-construction measures. The social adjustments indicated a psychological conflict between internal versus external responsibility.

Most of the respondents felt that they were responsible for their own problems while the remainder indicated that they would place responsibility for providing assistance on outside institutions: insurance and government. Of those who felt insurance would cover their losses only one individual was certain that he had an insurance policy which covered landslides, subsidence, and erosion. Due to the lack of knowledge on the part of the insurance firms questioned about this type of insurance being offered in Edmonton it is assumed that those who felt that they were covered under normal homeowner policies were mistaken. Through an investigation of the Statutes of the Government of Canada, the Province of Alberta, and the City of Edmonton, it was determined that there is no assistance available to individual homeowners for damages caused by natural exogenetic processes (excluding natural disasters).

Half of the sample population believed that no government help should be available to the homeowner who lives along the river valley, they felt that it was their personal risk, caveat emptor. The remaining 50 per cent felt government assistance should be available, with most

of it coming from the City. An examination of existing statutes shows that the City is not responsible for providing such assistance except during emergencies.

Therefore, it can be said that the owner-resident must depend upon his own knowledge of the situation and his own resources rather than on what others can do for him.

CHAPTER 5

IMPLICATIONS, APPLICATIONS AND CONCLUSIONS

I. INTRODUCTION

Man and his physical environment have become a field that has attracted professional and laymen in increasing numbers and audibility within the last few years. The major emphasis has been on underground nuclear explosions, industrial pollution, and water and air quality. There are many other environmental problems that are less emotional, such as raising lake levels or natural erosion. Man has come into contact with all these aspects of the physical environment which have been affected by him through his management of resources.

One implication of this study has been the need to bring together all points of view on resource management, on the management of erosion.

Several applications have been suggested from the research undertaken herein: One is the dissemination of information on the potential problem to groups and individuals concerned; a second application would be to attempt a codification of social adjustments across Canada and possibly

to compare Canada with other parts of the world.

Throughout this last chapter, within all three sections, there are ample suggestions that indicate what could possibly be done as further work not only on subjects in Edmonton but in the rest of the world.

II. IMPLICATIONS

The place of a geographer in the study of a natural hazard is unique. The geographer, when dealing with man-land relationships in a spatial structure, must come in contact with other sciences. The geographer borrows results from the civil engineer and geologist as these disciplines study the geomorphic processes that cause natural hazards. The concepts of social perception, cognitive processes, and attitudes are incorporated by the geographer from the psychological and sociological sciences. Through this interaction the geographer is able to present a study of the human spatial behavior. For the spatial structure has become "...recognized as a major explanatory variable of human behavior."[1]

There is a necessity for this interaction to be carried out to a much greater extent than has been done in

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[1] R. Abler, J. S. Adams, and P. Gould, Spatial Organization: The Geographer's View of the World, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1971, p. 88.

the past. There are at least four different points of view which can be incorporated by the geographer in a study of the erosional hazard in Edmonton: those of (1) the civil engineering consultants, (2) the City, (3) the behavioral scientists, and (4) the homeowners.

The civil engineer is concerned with providing advice on technical methods in combatting the particular problem under study and the economics involved. The engineer does not consider the social aspects of the problem, as he is concerned with solving the physical situation and not necessarily with the effect this will have on the human behavioral system.

The City is interested in maintaining its management of the river valley for parkland. It is also concerned with providing a transportation network which can best utilize the natural artery that the river valley provides through the City. In essence, the City is concerned with keeping the valley in essentially the same state of existence as it is in the present but at the same time it wishes to allow a minimal amount of disturbance for traffic needs. The City does not itself express a single ideal. The Parks and Recreation Department, the Planning Department, and the Engineering Department may, on occasion, give different opinions and hold separate points of view on what should be done in the river valley.

The behavioral scientists include psychologists, social psychologists, sociologists, and human geographers; they are concerned with the human behavioral system. Methods have been developed to establish and report cognitive processes, perception, and attitudes. Much research has been conducted by these behavioral scientists on the interaction of these processes and the individual's personal environment. It has only been of late that studies have been expanded to include the physical environment.

The last and most important cog in the wheel of interaction is the individual homeowner. The determination of what the individual homeowner aspires to and what his attitudes and perceptions are of the hazard and his homesite are all separate subjects that may be developed through research conducted by scientists (behavioral and otherwise). The geographer's role is to combine these different aspects and to improve on them by adapting the concepts of engineers and social scientists to studies of the individual homeowner, for in this manner there is a possibility that many views of the methods of resource management will be presented.

II. APPLICATIONS

There are two applications that can result from this study: (1) the publicity of the hazard, and (2) a general review of adjustments to the erosional hazard for Canada

and other parts of the world.

From the study it has been found that information is misunderstood or is not available to many people in the area. One particular example was the misinterpretation of the Crown rights, with regards to the North Saskatchewan River. When interviewed, two Alberta Supreme Court Justices, an engineer with the Federal Department of Public Works, and two planners in the City government were not aware of the Alberta Natural Resources Act of 1930 in which the Government of Canada turned over all public lands to the Province of Alberta (excluding Indian Reserves, Defense installations, and National Parks). It would be very possible that publication of material like this study would clear up this misunderstanding.

The individual homeowner, in many situations, is not aware of the lack of insurance coverage or the non-existence of government assistance programs that may face him should he live on a homesite adjacent to ravines or the river valley. There is a need for a requirement by the City that prospective homeowners be made aware of these difficulties. This could be done at two levels. One would be for the City to warn those who are applying for building permits. This approach, however, would only reach those who are building new homes. The second level at which prospective buyers could be warned is by the seller. This would include real

estate agents, land developers, and individual homeowners who are selling their own homes. The requirement of explaining the risks at this level would not be a popular by-law, it would be very possible that stringent opposition could be met from those required to explain the risk. The law relies on caveat emptor (Let the buyer beware) but this does not mean that one should attempt to "pull the wool over the eyes" of prospective buyers. The consumer has a right to be protected.

The second application is the compilation of social adjustments in the context of Canada as a whole and possibly compare it with other areas of the world. This should be done for all natural hazards to include flooding, coastal storms, hail, landslides, blizzards, and other meteorological phenomena. An attempt was made to investigate the social adjustments of insurance and government aid for Canada and other sections of the world concerning natural erosion. Three questions were asked of individuals experienced in areas of Eastern Canada, Scandinavia, and Latin America. The letters were written in English except for one letter in French that was sent to Quebec.

1. Does the government (at any level) provide compensation to individual homeowners who suffer damages from landslides, subsidence, or other natural erosional processes?

2. What building restrictions, if any, are set by governments in areas that are prone to natural erosional pro-

cesses? (This would include geologic and engineering tests.)

3. Do private or government insurance companies extend coverage for landslides or subsidence?

Preliminary results have been obtained from Eastern Canada (1), Scandinavia (2), and Latin America (1). Much of that which concerns Eastern Canada has been reviewed in the text and was derived from a study of sensitive clays in the Ottawa area.[2] Burton[3] has noted that compensation from hazards varies according to the circumstances and the magnitude of the event. In Ontario the government does not pay compensation to those homeowners living on Scarborough Bluffs where Lake Ontario is eroding the shores at a phenomenal rate (though it is not considered disastrous). It was noted in Chapter 4 that this area of Toronto ceased receiving landslide coverage from insurance firms in 1959 because the erosion could no longer be considered a risk and was now inevitable. Whereas in the St. Jean-Vianney quick clay disaster of 1971 the Quebec government provided compensation to the survivors.

> *In general, it seems true to say that government compensation is more likely when the event is sudden (a big slide rather than slow*

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[2] J. G. M. Parkes, Awareness of and Adjustment to a Natural Hazard: Sensitive Clays in the Ottawa-Hull Region, Dept. of Geogr., Univ. of Western Ontario, Unpublished M.A. Thesis, April 1971, 159 pp.

[3] Dr. I. Burton, Dept. of Geogr., Univ. of Toronto, Letter dated September 28, 1971, 2 pp.

> *erosion) and where many people are involved. And vice-versa. If you are going to suffer loss it is better to do it in the company of others!*[4]

From the second question there is an indication that amongst Canadian government planners there is little awareness of natural hazards when building restrictions are adopted. Burton feels this is especially pronounced in two Canadian cities, Toronto and Calgary. He notes that "...zoning and building restriction in areas prone to erosional processes is little studied and even less recognized as a necessary governmental function."[5] It is to the credit of Edmonton that its City planners have begun to recognize and zone for this problem in new areas of the City.[6]

Private insurance for landslides as explained by Parkes[7] is comparable to the situation in Edmonton. There is no coverage of landslides. Burton found that "...the private home-owner policies of St. Jean-Vianney did not cover that landslide disaster."[8]

It can be seen that the differences between Edmonton and Eastern Canada are slight. It would, of course, be im-

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[4] Ibid., p. 1.

[5] Ibid.

[6] Minutes of the City Council, City of Edmonton, Limit of River Valley and Ravine Study, July 22, 1970.

[7] Parkes, op. cit., footnote 2.

[8] Burton, op. cit., footnote 3, p. 1.

possible to make any concrete statements from these two sources and this study. There is a need to attempt further study of this problem in Canada.

It is interesting to note the preliminary results of two other areas in the world, both of which are at extremes to each other: Latin America and Scandinavia.

Latin America (excluding Mexico and British Honduras) would be the negative extreme. Homeowners insurance does not exist nor is there any restrictions on the construction of homes. This is especially evident in the large cities such as Rio de Janeiro, Brazil, where slum housing is built on overly steep hillsides. During torrential rains huge mudflows often sweep the hills bare. The only aid that is offered is that of immediate disaster relief which often comes from the rest of the world through the Red Cross. No compensation to homeowners is provided. To attempt to place these sections of Latin America in to the North American context of social adjustments is not possible.[9]

Scandinavia (at least Norway and Sweden) on the contrary have much more developed policies on erosional adjustments. In both countries the national governments have established disaster compensation funds, regardless of

[9] Dr. J. F. Bergmann, Dept. of Geography, Univ. of Alberta, Pers. comm., September 9, 1971.

what types of disasters they are. In Norway this institution is the National Disaster Foundation (the Norwegian term is Naturskadefondet).[10] The fund compensates homeowners up to 75 per cent of the market value of the house. This foundation will also provide the financial support for protection measures to prevent quick clay landslides. The Swedish have the Government Fund for National Disasters,[11] unlike its Norwegian counterpart there are no set compensation rates as each case is reviewed for its own merits by a central office.

Building restrictions are extremely tight in both countries for areas subject to natural erosional processes. In Sweden the responsibility in on the municipality whereas in Norway it rests with the individual. Since 1969 the Norwegian government has required prospective home builders (and anyone else planning any type of construction) who wish to construct in areas prone to natural disasters to have thorough geologic tests run on the area.[12] In Sweden the law requires all town and city plans be prepared and based on geotechnical investigations. This investigation and

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[10]Dr. G. Østrem, Glaciology Section, Norwegian Water Resources and Electricity Board, Oslo, Norway, Letter dated September 27, 1971, 1 page.

[11]Dr. J. O. Norrman, Dept. of Physical Geography, Univ. of Uppsala, Sweden, Letter dated October 6, 1971, 1 page.

[12]Østrem, op. cit., footnote 10.

subsequent planning must take into account landscape character and ground stability.[13] These two Scandinavian requirements are a marked difference from the Edmonton situation or even that of Quebec and Ontario planning laws, where there are similar quick clay conditions.

The policy on homeowners insurance is remarkably different. Norway does not have insurance to cover landslides while Sweden does. The reason that Norwegian firms do not offer insurance coverage is because the National Disaster Foundation gives compensation. Swedish private insurance firms offer both landslide and earthquake coverage in ordinary home insurance policies.

The comparison of social adjustments on an international scale is not only a necessary application of this study but it is also interesting. Further correspondence is being carried out to investigate these aspects of compensation, planning, and insurance for Canada and the world.

IV. CONCLUSIONS

The thesis has been directed towards the goal of establishing behavioral links between geomorphology and human geography. It is an attempt to relate perception of a population which through choice has come in contact with

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[13] Norrman, *op. cit.*, footnote 11.

a geomorphic process. Whether or not the population is aware of this process is the most important question in perception studies. The thesis has produced mixed responses, some positive, some negative, and some inconclusive. The major point is that it has presented information of a spatial problem which continues through time and can cause a continual behavioral reaction.

Six hypotheses were presented of which only three could be statistically tested. The major hypothesis stated that people perceived the erosional hazard when they establish their residency on the top of the river valley. From the data collected by personal interviews this hypothesis was rejected. The subordinate hypothetical statement of the major hypothesis proved valid, it stated that more than half of the people _at present_ perceive the erosional hazard. It was hypothesized that well educated people would be more aware of the erosional hazard both initially and at present. However, statistical tests showed that this was only a valid assumption for well educated residents and _present_ perception. Present perception and higher investment (correlated from assessment values) were also expected to have a proportional relationship but the data proved insignificant when applied to the chi square test. No relationships were found to exist between older persons and pessimism about future occurrences of the erosional

hazard despite a weak correlation established in a flood hazard study. The data indicated that there might even be a younger person-pessimistic relationship present, though this was not evident in the test results. The last hypothesis concerned technical adjustments, it was thought that people did not believe erosion could be controlled or prevented by technical adjustments. It was found, however, that this was not a valid statement. Over 80 per cent of the population sampled believed that technical adjustments could prevent or impede natural erosion.

The major concentration in this study was the individual's adjustments to the erosional hazard. Adjustments were divided into two types: technical and social. Technical adjustments were further subdivided into two types of measures: (1) those that should be attempted prior to construction and (2) those that can be taken after the homesite is established. Social adjustments investigated were (1) homeowners insurance and (2) government aid. Each of these were studied intensively by interviews, correspondence, and through review of the Statutes of Canada and the Province of Alberta. It was found that half of the sample felt government aid should be available. It is not (except in the case of disasters). Homeowners insurance was likewise found to be almost non-existing concerning landslide, subsidence, and erosion coverage.

Two possible concluding remarks can be made about this study. It would be interesting to observe whether or not the governmental regulations on construction in hazardous zones, as used in Scandinavia, could be applied to North America. Would such a step eliminate financial and legal problems in an area such as Edmonton?

The second remark would be to note the major need that this study has found. It has shown the need for a comprehensive publicity program. It must be completed by the government (at any level but preferably the City) to make the population of Edmonton aware of the physical problems and lack of insurance and government aid that could affect current and potential river valley homeowners.

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APPENDIX A

FINAL QUESTIONNAIRE

QUESTIONNAIRE

Section A: To be completed prior to the interview.

a. Date ____________________

b. Location in Edmonton

Area of Edmonton __________________

Adjacent to the River Valley ________

or

Adjacent to a ravine or gully _______

Section B: To be answered by respondent.

1. Sex: M F

2. Age: _________

3. Occupation: (Place in correct category)

a. Managerial
b. Professional and Technical
c. Transport and Communication
d. Clerical
e. Sales
f. Service and Recreation
g. Craftsmen, production, process and related workers
h. Laborer
i. Housewife
j. Retired
k. Other (Specify) __________________________

4. Highest Education Level:

a. High School
b. Less than High School, (how many years completed) _____
c. Trade or Technical School
d. University (number of years if did not complete) (including advanced degrees)
e. Other (Specify) __________________________

5. a. What are the principal advantages of living at this particular location? _________________________________

____

b. What are the principal disadvantages? ______________

____

6. What year did you move here? _______

Are you the original owners? _______

If no, what year was this house built? _______

7. Were you aware of the problem of natural erosion when you bought this lot?

Yes _____ No _____

8. Have you ever noticed any natural erosion in your immediate neighborhood since you have lived here?

Yes _____ No _____

a. If yes, do you remember one year in which frequent erosion was evident?

Yes _____ No _____

b. If yes, in what year? _________

9. a. Do you think natural or man-induced erosion will occur on your property during your lifetime?

Yes _____ No _____

b. If so, soon _____; In a few years _____;
Not in your lifetime _____.

10. Do you know of any places in the City, other than your own neighborhood, in which natural erosion has occurred?

Yes _____ No _____ Don't Know ____

a. If yes, where? _____________________________________

11. a. Do you think you will live on this lot many more years?

Yes _____ No _____ Don't Know _____

b. Assuming you were to move, where would you prefer to go (Card #1)?

1. In Edmonton, along the River or ravine valleys ____
2. In Edmonton, but away from the River system _____
3. Out of Edmonton, but remain in Alberta _____
4. Out of Alberta _____

12. If you were to suffer loss (to your property or house) from natural erosion, to whom can you go for assistance in recovering these losses?

Family, _____, Friend, _____, Insurance, _____,

Government (including loans), _____, Private Money

Lending Institution (or Charter Bank), _____, Other

(Specify), _____, Nobody, _____.

13. If you have ever suffered such losses from erosion, have any of the above ever helped you successfully?

Completely _____, Somewhat Successfully _____,

Somewhat Unsuccessfully _____, Unsuccessfully _____,

Don't Know _____.

14. Do you know anyone who has been helped by the Government (City, Provincial or Federal) because of erosional problems?

Yes _____ No _____

If yes, how? ____

____

15. Are there any signs or indicators that would tell you that some type of erosion was about to occur?

Yes _____ No _____

If yes, please explain: ______________________________

____

16. a. Is there anything that you can do or would recommend to prevent damage caused by natural and man-induced erosion?

Yes _____ No _____ Don't Know _____

b. If yes, what? ____________________________________

____

17. a. Is there anything the City can do to prevent erosional damages?

Yes ______ No ______ Don't Know ______

b. If yes, what? ________________________________

____

18. a. Is there anything the Provincial Government can do?

Yes ______ No ______ Don't Know ______

b. If yes, what? ________________________________

____

19. a. Is there anything the Federal Government can do?

Yes ______ No ______ Don't Know ______

b. If yes, what? ________________________________

____

20. a. Do you think government help should be available to people who suffer damages from natural erosion?

Yes ______ No ______ Don't Know ______

b. If answer to (a) is yes, what level of government?

____

c. If answer to (a) is yes, why should the government make such help available?

____

____

APPENDIX B

BUILDING AND LAND
ASSESSMENT FORMULAS

Building and land assessments are determined by the City of Edmonton for tax purposes. Each is taken separately. Land assessment is closer to actual market value than building assessment. All assessments will be raised within the next two years as the City is reviewing its figures in 1971 and 1972. In this present reassessment an additional formula for those lots that are adjacent to the scenic ravines and river valley will be computed, it has not been established as of this writing. It should approximate the market value much better than the system in present use. The mil rate is taken from the assessed value of both figures computed.

The formula shown are simplified from the written document that the City Assessment Department uses.[1]

---

1. L. D. McCann, PhD Candidate, Dept. of Geogr., Univ. of Alberta, Pers. comm., September 21, 1971.

Building Assessment Formula for Single Family Dwellings

$$A = \frac{(C \div 0.75) - nD}{0.50}$$

where A is Assessed Value
C is Material and Labor Cost in 1957
D is Depreciation of 1% per year of C
n is number of years

Land Assessment (three formulas)

$$T = S - (H \times 53.3) \qquad (1)$$

where T is True Land Price, as of 1971, for an area

S is Total Sales for all lots for one year in that area

H is sum of total building appraisals in the same area (total of A above)

53.3 is Difference of cost of land in 1962 and 1971 as determined by the Provincial Department of Municipal Affairs

$$E = (T \div F)0.65 \qquad (2)$$

where E is Effective value per foot in property frontage

T see first formula, above

F is Total effective frontage for all lots in the certain area of S, above

$$L = (Z)E \qquad (3)$$

where L is Land Assessment

Z is number of feet in frontage per lot

E see second formula, above

APPENDIX C

FORM LETTER,

FOLLOW UP LETTER,

AND

REPLY CARD

DEPARTMENT OF GEOGRAPHY

THE UNIVERSITY OF ALBERTA
EDMONTON 7, CANADA

May 7, 1971

Homeowners Study

Dear

I am a graduate student in the Department of Geography at the University of Alberta, I am engaged in research concerning the choice of home sites by their owners in Edmonton. As part of this study I am anxious to determine why you chose your home site and what problems you might have with it. To this end I would be very grateful if you would permit me to interview you.

Enclosed you will find a prepaid postcard, please indicate by checking the appropriate box if you wish to participate in this study, and return the postcard to me through the mail.

I would be very appreciative of your cooperation in this research project.

Sincerely yours,

Patrick W. Naughton

DEPARTMENT OF GEOGRAPHY

THE UNIVERSITY OF ALBERTA
EDMONTON 7, CANADA

QUAECUMQUE VERA

June 9, 1971

Dear

Recently you received a letter inviting you to participate in a homeowners study of residents within the City of Edmonton. To date, I am missing a number of reply postcards that were enclosed in that letter. Without your reply, the study itself will suffer.

If, however, you have already forwarded the reply card, please ignore this request and accept my thanks for your time spent.

Your cooperation in this matter is greatly appreciated.

Sincerely yours,

Patrick W. Naughton

☐ I do not wish to participate

☐ I would like to be interviewed, the best time of day to interview me is ______________________________

☐ I would like to be interviewed but would appreciate it if you made an appointment, my phone number is ______________________________

REPLY CARD

APPENDIX D

INSURANCE INQUIRY LETTER

DEPARTMENT OF GEOGRAPHY

THE UNIVERSITY OF ALBERTA
EDMONTON 7, CANADA

QUAECUMQUE VERA

August 21, 1971

-------- Insurance Co.
17445-106th Avenue
Edmonton, Alberta

Dear Sirs:

I am a graduate student in the Department of Geography at the University of Alberta. For the past several months I have been conducting research into the perception of residents who live along the North Saskatchewan River Valley to the problems caused by natural erosion.

One of the questions I have asked the homeowners was to whom can they go to recover loss to their property and/or home, if the damage was caused by natural erosion. Approximately 18% responded that they would go to their insurance company. I did not ask these individuals from which company they obtained coverage as that would have been an invasion of privacy.

What I have done instead is to consult the yellow pages and I chose your company from the listing of types of insurance that you offer. Any information that you provide to the below questions will be strictly confidential. If you wish to confirm my status please do not hesitate to call the Department of Geography at 432-4783 or me at 432-5624.

My questions are:

1. Do you designate certain areas of the City as possible insurance risks? If so, which areas?
2. When you write a policy for a single family dwelling, along the river valley or a ravine, do you normally include landslide or subsidence insurance coverage?
3. Do you sell special landslide or subsidence insurance? If so, is the cost much higher than an ordinary homeowners policy?
4. What is your definition of the phrase "Act of God" (vis major) in regard to homeowners insurance?

I have included a self addressed stamped envelope for your reply. In advance, let me say that I am extremely grateful for any information that you can provide.

Sincerely yours,

Patrick W. Naughton

APPENDIX E

COMPUTATIONS FOR
CHI SQUARE TESTS

APPENDIX E

Computations for Chi Square Tests

TABLE XIV Expected and Observed Frequencies of Education Level and Initial Perception

Education Level	Yes		No		Total
	Ex.	Ob.	Ex.	Ob.	
High School or less	7.3	6	11.7	13	19
Above High School	15.7	17	25.3	24	41
Total		23		37	60

Expected Frequencies for H.S. or Less $= \frac{23 \times 19}{60}$ and $\frac{37 \times 19}{60}$

Expected Frequencies for above H.S. $= \frac{23 \times 41}{60}$ and $\frac{37 \times 41}{60}$

Degrees of Freedom = (R-1) (C-1)= 1

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

$$= \frac{(6-7.3)^2}{7.3} + \frac{(17-15.7)^2}{15.7} + \frac{(13-11.7)^2}{11.7} + \frac{(24-25.3)^2}{25.3}$$

$$= \frac{(-1.3)^2}{7.3} + \frac{(1.3)^2}{15.7} + \frac{(1.3)^2}{11.7} + \frac{(-1.3)^2}{25.3}$$

$$= \frac{1.69}{7.3} + \frac{1.69}{15.7} + \frac{1.69}{11.7} + \frac{1.69}{25.3}$$

$$= 0.231 + 0.107 + 0.144 + 0.067$$

$= 0.549$ with one degree of freedom

TABLE XV Expected and Observed Frequencies of Education Level and Present Perception

Education Level	Yes Ex.	Yes Ob.	No Ex.	No Ob.	Total
High School or Less	10.8	7	8.2	12	19
Above High School	23.2	27	17.8	14	41
		34		26	60

Expected Frequencies for H.S. or Less $= \frac{34 \times 19}{60}$ and $\frac{26 \times 19}{60}$

Expected Frequencies for above H.S. $= \frac{34 \times 41}{60}$ and $\frac{26 \times 41}{60}$

Degrees of Freedom = (R-1) (C-1) = 1 degree

$$\chi^2 = \sum \frac{(0-E)^2}{E}$$

$$= \frac{(7-10.8)^2}{10.8} + \frac{(27-23.2)^2}{23.2} + \frac{(12-8.2)^2}{8.2} + \frac{(14-17.8)^2}{17.8}$$

$$= \frac{(-3.8)^2}{10.8} + \frac{(3.8)^2}{23.2} + \frac{(3.8)^2}{8.2} + \frac{(-3.8)^2}{17.8}$$

$$= \frac{14.44}{10.8} + \frac{14.44}{23.2} + \frac{14.44}{8.2} + \frac{14.44}{17.8}$$

$$= 1.337 + 0.623 + 1.761 + 0.812$$

= 4.533 with one degree of freedom

TABLE XVI Expected and Observed Frequencies of Assessment Values and Present Perception

	Assessment Values				
	Less than $15,000		More than $15,000		Total
	Ex.	Ob.	Ex.	Ob.	
Perceived	18.7	17	15.3	17	34
Not Perceived	14.3	16	11.7	10	26
		33		27	60

Expected Frequencies for Perceived $= \frac{33 \times 34}{60}$ and $\frac{27 \times 34}{60}$

Expected Frequencies for Not Perceived $= \frac{33 \times 26}{60}$ and $\frac{27 \times 26}{60}$

Degrees of Freedom = (R-1) (C-1) = 1 degree

$$\chi^2 = \sum \frac{(0-E)^2}{E}$$

$$= \frac{(17-18.7)^2}{18.7} + \frac{(16-14.3)^2}{14.3} + \frac{(17-15.3)^2}{15.3} + \frac{(10-11.7)^2}{11.7}$$

$$= \frac{(-1.7)^2}{18.7} + \frac{(1.7)^2}{14.3} + \frac{(1.7)^2}{15.3} + \frac{(-1.7)^2}{11.7}$$

$$= \frac{2.89}{18.7} + \frac{2.89}{14.3} + \frac{2.89}{15.3} + \frac{2.89}{11.7}$$

$$= 0.155 + 0.202 + 0.189 + 0.247$$

$= 0.793$ with one degree of freedom

TABLE XVII <u>Expected and Observed Frequencies of Pessimism and Age Groups</u>

	Younger than 46		46 and Older		Total
Future Occurrence (Pessimism)	Ex.	Ob.	Ex.	Ob.	
Soon	4.3	6	8.7	7	13
Not In Life Time (or Never)	15.7	14	31.3	33	47
		20		40	60

Expected Frequencies for Soon = $\frac{20 \times 13}{60}$ and $\frac{40 \times 13}{60}$

Expected Frequencies for Not in Lifetime = $\frac{20 \times 47}{60}$ and $\frac{40 \times 47}{60}$

Degrees of Freedom = (R-1) (C-1) = 1 degree

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

$$= \frac{(6-4.3)^2}{4.3} + \frac{(14-15.7)^2}{15.7} + \frac{(7-8.7)^2}{8.7} + \frac{(33-31.3)^2}{31.3}$$

$$= \frac{(1.7)^2}{4.3} + \frac{(-1.7)^2}{15.7} + \frac{(-1.7)^2}{8.7} + \frac{(1.7)^2}{31.3}$$

$$= \frac{2.89}{4.3} + \frac{2.89}{15.7} + \frac{2.89}{8.7} + \frac{2.89}{31.3}$$

$$= 0.672 + 0.184 + 0.332 + 0.093$$

= 1.281 with one degree of freedom


EDMONTON
Study Areas
Number of Respondents
Limit of Top of Bank
Thalwegs and Direction of Flow
Recent Landslides
Coal Mine Workings
Entrance to Coal Mines
Subsidence of Coal Mines
Recent River Erosion
SOURCES:
1. R.S. Taylor. Atlas: Coal-mine Workings of the Edmonton Area. (Edmonton. S. Taylor and Assoc. Ltd. 1971). 33 pages
2. S. A. Hamilton. M. A., Pers. Comm., Sept. 1971
3. Field Work, 1967-68 and 1970-71
Highlands
Gold Bar
Capilano Bridge
Rowland West
Rowland Capilano
Dawson Bridge
Taylor Hill
Cameron Avenue
Grierson Hill
Low Level Bridge
James Macdonald Bridge
Connors Hill
Strathearn
Mill Creek Ravine
Queen Elizabeth Park
N
Provincial Legislature Bldg.
High Level Bridge
105 th Street Bridge
University of Alberta
Windsor Park
Saskatchewan Drive West
Groat Ravine
Groat Bridge
St. Georges Crescent
Summit Point
Riverside Crescent
Mc Kenzie Ravine
Valley View
North Saskatchewan River
Quesnell Crescent
Quesnell Bridge
Rio Terrace
Grand View
Whitemud
Westbrook
Mile

Figure 2

B30015